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Cover art: Paleontological reconstruction of Rodan (artwork by: Scott Reid)

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The One Born of Fire: a pterosaurological analysis of Rodan

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Rodan is a giant monster, or kaiju, created by Toho Studios (Tokyo, Japan). First appearing in 1956 in its own movie (aptly named *Rodan*), the monster has since become strongly associated with the Godzilla franchise (Fig. 1). Rodan has appeared in seven movies (not counting cameos through stock footage), including the recently released *Godzilla: King of the Monsters* (2019).

Although often compared to birds, Rodan is explicitly based on pterosaurs. In fact, its Japanese name ラドン *Radon* is a contraction of the name of the pterosaur genus *Pteranodon*, and its design reflects this. Rodan's head, with its toothless beak and curved crests, is clearly based on that of Pteranodon. The original Rodan's crest shape bears a particular resemblance to specimen YPM 2594[1], a fossil of an adult male *Pteranodon longiceps* (Fig. 2).

Figure 1: Rodan through the years. Clockwise from top left: Ghidorah, the Three-Headed Monster (1964); Godzilla: King of the Monsters (2019); Godzilla: Final Wars (2004); Rodan (1956); Godzilla vs. Mechagodzilla II (1993). Images extracted from Wikizilla.

[1] The specimen is kept in the collection of Yale Peabody Museum of Natural History (New Haven, USA).

Figure 2: Three real pterosaurs for comparison: *Pteranodon longiceps*, *Dsungaripterus weii*, and A*rambourgiania philadelphiae*. All courtesy of Julio Lacerda, https://www.pteros.com/, which is a great website about pterosaurs that I highly recommend.

COMPARISON TO ACTUAL PTEROSAURS

Anatomy

Of course, given the first movie starring Rodan came out in 1956, when Pterosaurology was still in its infancy, it is by no means an accurate depiction of a pterosaur. The first difference, obviously, is size. Depending on the incarnation, Rodan has a wingspan between 120 and 265 meters (Table 1 and Fig. 3; Wikizilla, 2019). The very largest pterosaurs belonged to family Azhdarchidae, with giants such as *Quetzalcoatlus* and *Arambourgiania* (Fig. 2) reaching roughly 11-meter wingspans. This is near the largest estimated size a pterosaur can get and be able to launch itself off the ground and stay airborne (Witton & Habib, 2010). Rodan is also very different proportionally from the largest pterosaurs known. Azhdarchids generally had giant heads, long necks, very long limbs, and tiny, tiny bodies (Habib, 2019). Rodan, in contrast, has relatively short limbs and a long torso. Given from 1956 to 2004 he was portrayed by the "suitmation" typical of *tokusatsu* movies (Fig. 1), this is understandable from an out-of-universe perspective.

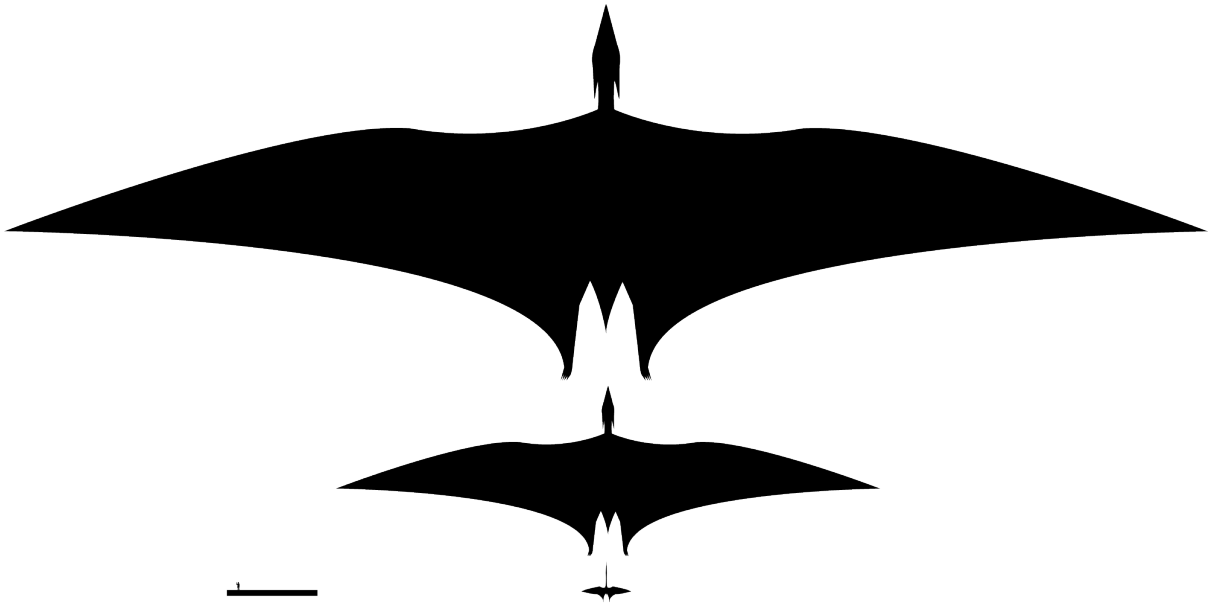

Figure 3: Size comparison of Rodan at his largest (top; *Godzilla: King of the Monsters*, 2019) and smallest (middle; Rodan, 1956), compared to a 11-meter *Quetzalcoatlus* (bottom). Scale bar = 20 meters, and that tiny speck standing on it is a person. *Quetzalcoatlus* silhouette courtesy of Mark P. Witton & Darren Naish, via PhyloPic (http://phylopic.org/).

Table 1: Appearances and sizes of Rodan throughout the years. He's been getting bigger. Data from Wikizilla and Toho Kingdom (http://www.tohokingdom.com).

Film	Year	Height	Wingspan	Weight (in metric tons)
Rodan	1956	50 m	120 m	15,000 t
Ghidorah, the Three-Headed Monster	1964	50 m	120–150 m	15,000 t
Invasion of Astro-Monster	1965	50 m	120–150 m	15,000 t
Destroy All Monsters	1968	50 m	120–150 m	15,000 t
Godzilla vs. Mechagodzilla II	1993	70 m	120 m	16,000 t
Godzilla: Final Wars	2004	100 m	200 m	30,000 t
Godzilla: King of the Monsters	2019	46.9 m	265.5 m	35,419 t

Rodan's skull is much smaller proportionally than most pterosaurs. Even small-headed pterosaurs have large skulls proportionally, compared to other reptiles. In particular, large pterosaurs like azhdarchids, anhanguerids, *Pteranodon* (Fig. 4), and *Thalassodromeus* have proportionally massive skulls. Huge heads, surprisingly, conveyed certain advantages. They likely made takeoff easier – pterosaurs took off by catapulting themselves into the air from a quadrupedal position, and large heads would make this easier by shifting the center of gravity forwards. In flight, the massive heads were relatively light and aerodynamic (Habib, 2019). As Rodan takes off bipedally – a consequence of being portrayed by suitmation for 48 years – the same benefits may not apply.

Figure 4: As an aside, this is the largest Pteranodon skull I am aware of, at the Natural History Museum of Los Angeles County (USA). This thing is a monster. When reconstructed, it is longer than the author is tall. Photo by the author.

Rodan's skull also has both a toothless anterior beak and posterior teeth. *Pteranodon* does not have teeth (its name literally means "toothless wing"), and neither do azhdarchids (Fig. 2). A combination of a toothless anterior beak and posterior teeth is only known in two pterosaur families: Dsungaripteridae and Rhamphorhynchidae, both of which are much smaller. Like many pterosaurs, including Pteranodon, Rodan also has a crest on the posterior end of its skull. However, in all pterosaurs with posterior head crests, there is only one crest, projecting from the midline of the skull. This crest is paired in most of Rodan's appearances. The sole exception is in *Godzilla vs. Mechagodzilla II*, where Rodan has three crests: one midline crest and two smaller crests flanking it. Presumably, this was done because it looks cool, and not as a bid for scientific accuracy.

Rodan walks upright on two legs in almost every appearance (Fig. 1), a consequence of being portrayed via suitmation. This was accurate at one point (e.g., Padian, 1983), but trackways and biomechanics now show that all pterosaurs walked quadrupedally. That said, Rodan always stands plantigrade, as real pterosaurs did (Witton, 2015). Surprisingly, though, in its original appearance, Rodan's wing membranes appear to go all the way down to the ankles. This is in line with fossil evidence, which shows that pterosaur wing membranes attached at the ankles instead of the hips or knees (Elgin et al., 2011). The wing membranes are also portrayed as thick and fleshy, which is similar to the wing membranes (patagia) of actual pterosaurs. Pterosaur patagia were more complex than the thin, veiny wings they're sometimes portrayed with – they had a muscular layer and were supported by fibers called aktinofibrils (Witton, 2013). These two traits of the wing membrane are things even recent movies like *Jurassic World* (2015) get wrong, and it's likely Toho got them right by accident.

In almost every appearance, Rodan is covered by bare, leathery skin, with large pointed plates (scutes) on the belly. This is in contrast to actual pterosaurs, which as far as we know were universally covered in a type of fuzz called pycnofibres. This fuzz likely shares an evolutionary origin with the feathers of birds, albeit not being as complex (Yang et al., 2019). Large scutes would add weight and probably negatively impact flight ability. However, the recent *Godzilla: King of the Monsters* takes a new and interesting direction, where Rodan is instead covered with a rocky armor. It is implied in supplementary marketing material that this armor is tied to a magmatic physiology, which we can probably safely say was not present in any real pterosaur.

As a side note, there is a lone outlier in portrayals of Rodan. The opening montage of *Godzilla: Planet of the Monsters* (2017) briefly shows the skeleton of Rodan, and it is identical to that of a male *Pteranodon longiceps*. Presumably, it would have also been identical in life.

Behavior

As a giant monster, Rodan's behavior does not accurately reflect that of real pterosaurs either. Rodan can create powerful gusts of wind and destructive shockwaves in flight, which would have been impossible for any real pterosaur (Mike Habib, pers. comm.). In *Godzilla vs. Mechagodzilla II* (1993), when exposed to radiation, Rodan turns into Fire Rodan and gains a radioactive heat beam ability, similar to Godzilla's famous atomic fire breath. A weapon like this may be analogous to the defensive acid fired from the abdomen of the bombardier beetle; both are superheated and explosively fired (Dean et al., 1990). Although the presence of radioactive energy weapons does not preserve in the fossil record, it would be unprecedented within vertebrates, and we can probably safely presume no real pterosaurs were armed with one.

The original *Rodan* portrays two individual Rodans, a male and a female. The two are only different in coloration; one is a richer burgundy than the other. Drastic sexual dimorphism is known in some pterosaurs, such as *Pteranodon* and *Hamipterus*, where the crests and overall body size

of the males were significantly larger than those of the females (Bennett, 1992; Wang et al., 2014). Other pterosaur groups, such as azhdarchoids, appear to show no such skeletal dimorphism (Manzig et al., 2014; Brian Andres, pers. comm.), but this does not rule out other forms of sexual dimorphism, such as differing colorations. The two Rodans are implied to mate for life; when one falls into a volcano, the other sacrifices itself to join its mate in death. It is unknown whether any pterosaurs mated for life. The structure of *Pteranodon* populations, with more female individuals than males, implies polygamous lek mating similar to sea lions or grouse (Bennett, 1992), while the even sex makeup of *Hamipterus* colonies implies they may have been monogamous like modern seabirds (Wang et al., 2014).

There is one thing Toho got right with Rodan's behavior, however. In *Rodan*, an egg is discovered in a mine in Kitamatsu, on the southern Japanese island of Kyushu. The egg hatches, and the hatchling Rodan already has fully-developed wings and the ability to hunt Meganulons (a fictional species of giant prehistoric insects) on its own. Numerous fossils of pterosaur babies – also called flaplings – have been discovered. These flaplings already show adaptations for full flight, and it is thus likely that pterosaurs were superprecocial, i.e., babies could fend for themselves immediately after hatching (Witton, 2013). Toho seems to have gotten superprecocial pterosaurs right by accident, given this wasn't recognized until decades later. It's almost surprising; given Rodan's behavior generally takes cue from modern birds, one might have expected Rodan flaplings to be altricial, like birds of prey. As well, *Destroy All Monsters* (1968) portrays Rodan feeding on cetaceans, presumably an upgrade from the piscivory of large oceanic pterosaurs such as *Pteranodon* (Bennett, 1994). In contrast, large terrestrial pterosaurs such as azhdarchids were likely omnivorous or carnivorous, foraging for food on the ground instead of taking it from the air (Witton & Naish, 2008).

SPECULATIVE EVOLUTION

Suppose, for a second, Rodan was real. If you're anything like me, you may ask: where would it fall on the pterosaur family tree? To answer this question, I coded Rodan into a phylogenetic analysis of pterosaurs I've been working on (Thomas, 2018), using what anatomy I could infer from its

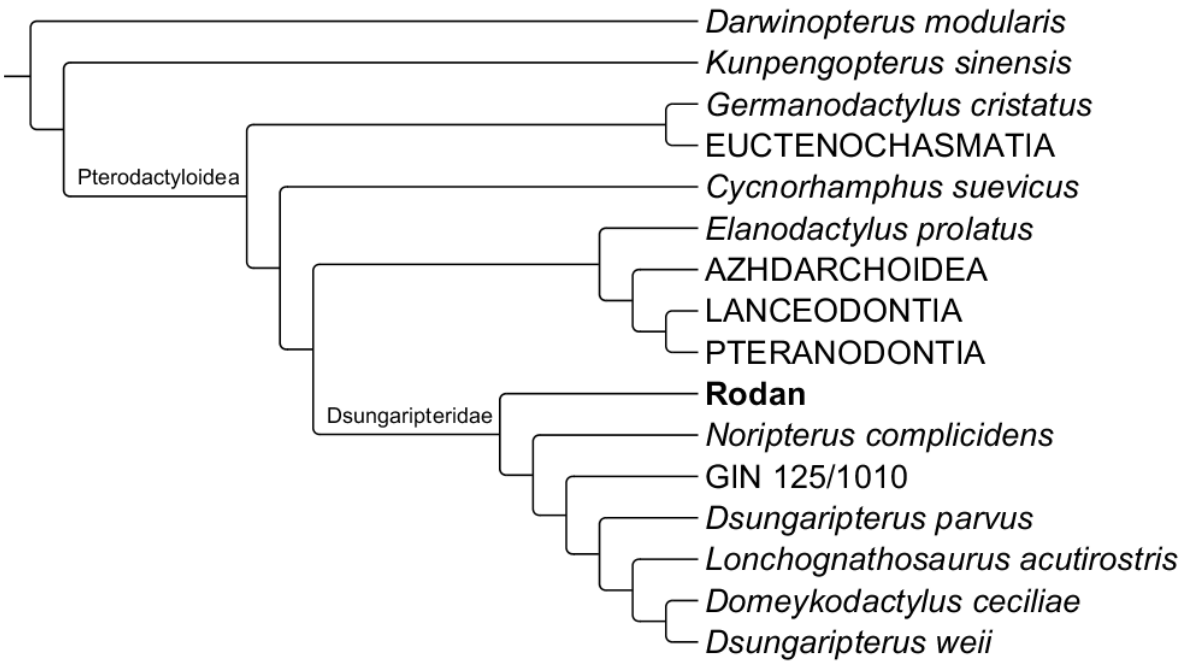

Figure 5: The phylogenetic position of Rodan among pterosaurs.

external appearance. Rodan ended up nowhere near *Pteranodon* or the giant azhdarchids, but inside Dsungaripteridae (Fig. 5). Dsungaripterids are the only pterodactyloids that have both toothless anterior beaks and posterior teeth, as Rodan does. The subtriangular skull outline and posterior crest of *Dsungaripterus* (Fig. 2) and *Noripterus* compare well with the outline of Rodan's head. Dsungaripterids are also noteworthy for having unusually thickened bone walls (at least 3 mm, compared to less than 2 mm in most pterosaurs) and overall being more robust than most pterodactyloids, traits that would befit a kaiju-sized pterosaur.

How might a real pterosaur resembling Rodan evolve? Let us speculate for a moment. We'll start with a dsungaripterid – perhaps the proportionally smallest-headed of all pterodactyloids. Increase the size, as well as the proportional wingspan. We can make a few changes to the shape of the skull, including emphasizing the brow ridge and pairing the crests. Given pterosaurs were covered with pycnofibres, and scutes of any sort would weigh down the animal, it would be unlikely to evolve in a pterosaur. We can emulate Rodan's chest scutes with stiff bristles, however; similar stiffened filaments can be found in other avemetatarsalians, such as a few bird species and the ornithschian Psittacosaurus (Mayr et al., 2016). We can also give this pterosaur stronger hindlimbs, and the habit of rearing bipedally, to emulate the classic suitmation portrayal of Rodan (Fig. 6).

Figure 6: Rodan, if it were somewhat more similar to actual pterosaurs. Artwork by Scott Reid.

PUBLIC RELATIONS

Since its first appearance, Rodan has become one of the more popular and recognizable giant monsters. It is considered one of the "big five" Toho kaiju, alongside fellow superstars Godzilla, Mothra, Mechagodzilla, and King Ghidorah. But is the portrayal of Rodan a cause for concern among science communicators? Probably not. We're talking about a pterosaur with a wingspan in the hundreds of meters who creates hurricane-force winds and can sometimes breathe atomic energy. The laws of physics are gleefully trodden upon in Toho's kaiju movies. It's fair to assume that nobody expects accurate scientific information from them, and from 1960 onwards the movies themselves never act like this is the case. It's as if Toho knows its movies are not the best place for science. A greater issue, I would say, would be media that purport to show real species of pterosaur, and yet propagate and enable common misconceptions anyways.

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Henry Thomas is a biology student at the University of California, Berkeley, and the world's leading expert on Rodan phylogeny. His main research interest is pterosaurs.

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Shadows of stained glass: an analytical look at animated horror

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One of my favorite "things of beauty" are stained glass windows. By themselves, they contain intricate works of art with vivid color palettes that overlay silhouettes of the outside world. They're like a dreamy, imaginative capture of the beauty of nature and of the precise capability of human to weave intricacy into the commonplace object. But what make stained glass an extremely unique medium is its shadow. The shadows stained glass windows cast serve a utilitarian architectural purpose (that of lighting insides of churches and other buildings) while being a deep expression of color and emotion (Figs. 1, 2). It is almost as if every stained-glass panel has the capability to tell a multifaceted story by itself.

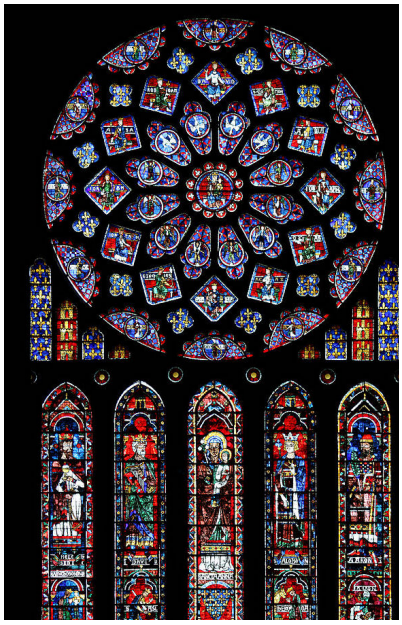

Figure 1: The north rose window of the Chartres Cathedral, France. Photograph by Eusebius (Guillaume Piolle), 2009; extracted from Wikimedia Commons.

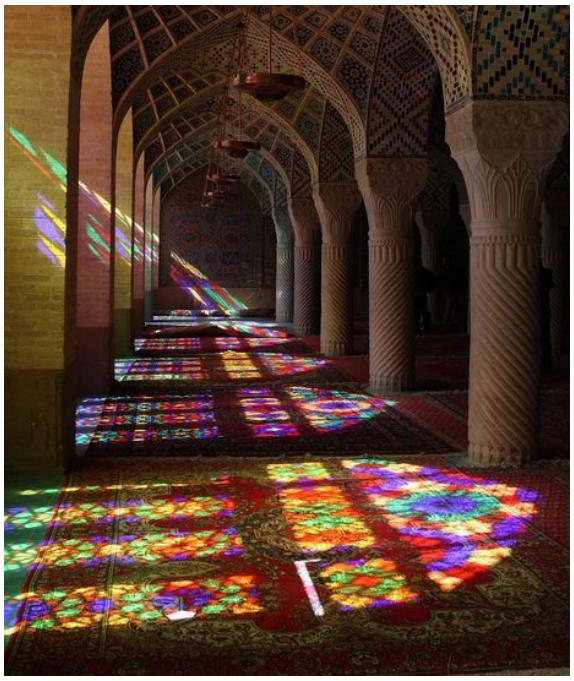

Figure 2: Nasir-ol-Molk Mosque, Shiraz, Iran. Unknown artist; extracted from Pinterest (imgfave).

Films, as an art form, have the unique ability to fully engage our auditory and visual senses, just like the beautiful imagery of stained glass. Unfortunately, a side effect of the format of films is that our untrained brains are so engrossed in the momentary frames that they tend to miss the larger patterns of filmmaking. They neglect the "shadows" films cast. Most of us give very little thought to the underlying philosophy of cuts, narrative structures and sound design.

In my essay, I want to explore the "shadows" of these stained-glass windows (i.e., films) to understand the patterns exhibit-

ed by the church (i.e., the art of filmmaking). I will take an objective, data-backed approach to analyzing films, using code to make observations about films. My project will primarily focus on the visuals of a film, and in particular, I will look at two seminal works, *Akira* (1988) and *Ghost in the Shell* (1995). I will utilize the atoms of a movie: the frames themselves. Using these frames, I will analyze color palettes and tones and look at some of the psychological underpinnings of color theory in film (and horror). Firstly, however, let's discuss some basic ideas of color theory and introduce the visualizations that will follow in the rest of this paper.

DIMENSIONS OF A FRAME

A picture is worth a thousand words.

By raw numbers, your average film is two hours long and uses the industry standard frame-rate of 23.976 frames per second. That means the average film is composed of $2 \cdot 60 \cdot 60 \cdot 23.976 = 172{,}627.2 \approx$ 170 thousand pictures. If the cliché saying is anything to go by, this rigorous analysis tells us that every film is worth about 170 million words. Since analyzing these 170 million words individually is beyond the scope of human lifetime, we need tools. In my paper, I employ graphic visualizations to summarize this data into something meaningful.

One of the most representative visualizations of a film is the **movie barcode**. A movie barcode is generated by taking every frame of a movie, extracting its dominant color, and skewing it to be only a pixel wide slice. By lining up these slices in a row, we can create a barcode-like image of an entire film. The dominant color of a frame is the most representative color based on a k-means clustering[1]. In its essence, a movie barcode is a method of compression that represents the movie in a single image.

Color, as an abstract concept, is very hard to describe. However, to make its study more discrete and accessible, computers and cameras use the HSL (Hue, Saturation and Luminosity) scheme to represent color. By definition, hue refers to the color of a point, as found along the spectrum or a color wheel (Fig. 3). Saturation indicates the intensity of a hue. Higher saturation hues appear 'stronger', for example being 'more red' or 'more blue'. Luminosity is a measure of how bright or dark a hue is. Physically, luminosity corresponds to amplitude and consequent energy of electromagnetic waves of light. To study these three characteristics, I visualize them in the form of **hue/sat/lum channel graph plots** (laid on top of the barcodes) and the **hue/sat/lum channel derivative plots** (which represent the change in the values expressed by these channels). To measure the perceived temperature of the film, I use a **Temperature Analysis plot**, which measures the distance of the hue of each frame from pure red, the color we perceive as warm/hot.

Figure 3: Color wheel.

To visualize the usage of each color, I use chord diagrams, which display the relationships between colors in frames. Each frame is arranged radially around, with the color transitions between frames drawn as arcs connecting the source with the endpoint. Consequently, this also visualizes the frequency of a color in the frames as well.

[1] https://en.wikipedia.org/wiki/K-means_clustering

AKIRA: CHROMA KEY

Even at a preliminary glance, the data (Figs. 4–9) reveals some interesting patterns that we would have missed otherwise. Let's break down some of the more obvious ones first, and dive into some more interesting analyses later.

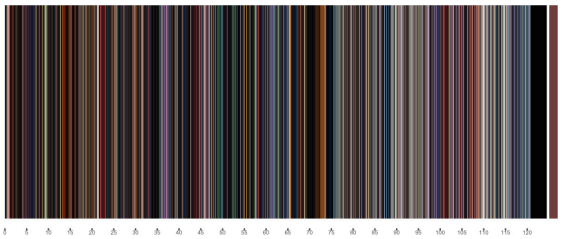

Figure 4: Barcode (finesse = 1 s).

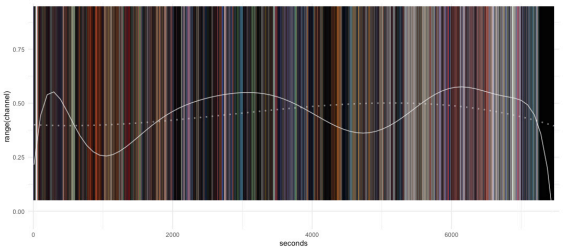

Figure 5: Hue channel (top) and its derivative (bottom).

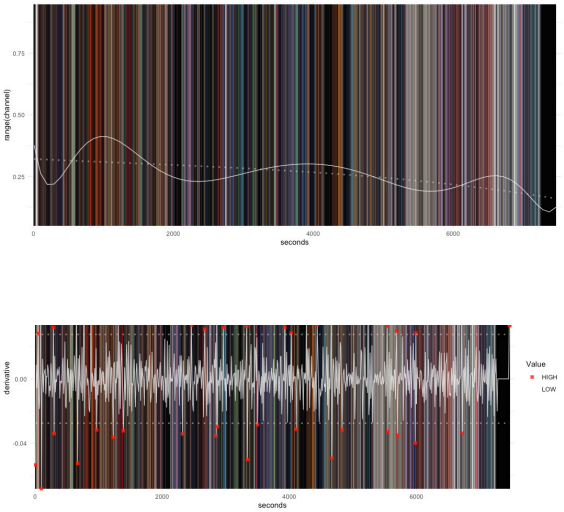

Figure 6: Saturation channel (top) and its derivative (bottom).

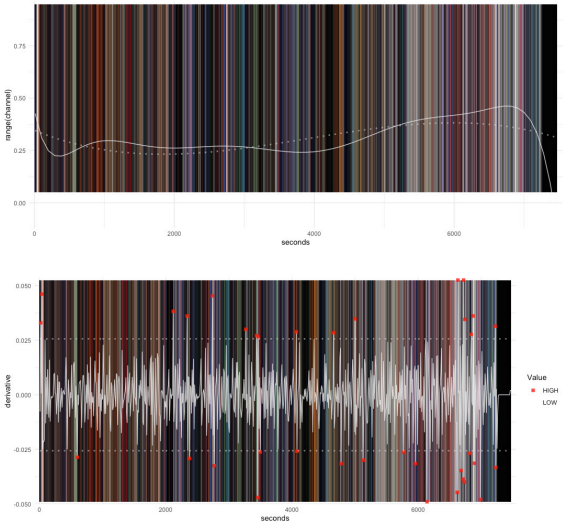

Figure 7: Luminance channel (top) and its derivative (bottom).

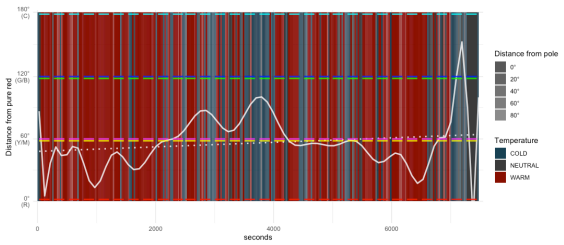

Figure 8: Color temperature analysis. The analysis follows an interesting trend during the second half of the film.

Figure 9: Chord diagram.

First, let us look at the temperature analysis' numbers (Fig. 8). This graph seems to show that in the first half, as the film progresses, the color palette of *Akira* starts feeling colder, with heavier shades of blue. In frames, this manifests itself as a transition from city shots and exciting bike chases to hospitals and sewers. The second half of this graph, on the other hand, shows a much more interesting transition. *Akira* uses color as a means to build up suspense and bakes the classic Freytag five-act structure's 'Act 4: Falling Action'[2] into its color scheme quite literally. This temperature analysis graph clearly shows that the entire second-half of the film is simply a giant build up to its concluding 'singularity'.

Secondly, observing the dips in this temperature analysis graph (Fig. 8), particularly the ones around 1,000 seconds and 6,500 seconds into the film, I noticed another interesting use of the color red in *Akira*: TRON streaks (Fig. 10). Throughout the film, *Akira* uses red and orange streaks of light that signify speed and agility, similar to the light trails *TRON* (1982) used for its light cycles. In a confusing, multi-storyline plot, these streaks remind the viewers' who they're rooting for. For instance, during the first bike chase, only our protagonists have bikes that leave behind trails. The antagonists are, on the other hand, on bikes that feel slow and unwieldy simply because they don't leave trails.

Figure 10: Hand drawn speed; 3:51.

Painting the "good" vs "evil" dichotomy

Mystery/horror stories often face a deep underlying challenge: how do you establish (and distinguish between) the "good" and the "evil" dichotomy while maintaining curiosity and fear in your audience's mind? This challenge, when used well, can be in fact a gift. I know my heart was racing at the moment Jordan Peele's Get Out (2017) revealed that Rose Armitage, one of the main characters, is actually a cold-hearted villain herself, when she's been built up all along to be on our protagonist's, Chris' team. This experimentation is not unique to screen-

[2] https://en.wikipedia.org/wiki/Dramatic_structure#Falling_action

writing. Even Sophocle's Oedipus Rex (ca. 429 BCE) sets up its tragic 'catharsis' moment by manipulating this dichotomy.

While Get Out and Oedipus Rex are clear-cut examples of the use of this dichotomy, *Akira*, on the other hand, does something absolutely stunning with this challenge: it subtly uses color to manipulate the audience's interpretations.

Let's take a look at the chord diagram of *Akira* again (Fig. 9). Notice something odd? Clearly, Katsuhiro Otomo shows a disproportionate amount of love for bloody, fiery shades of red and orange, but more interestingly, he seems to under-utilize the color green. It can't be a coincidence that an acclaimed artist such as Otomo specifically chose to underuse green, the G of RGB (one of the most popular characterizations of color space in art). I believe the use of green (or the lack thereof) holds very intentional purpose in Otomo's masterpiece.

Signaling with color

Otomo's sparing use of green makes it a rather easy color to analyze. Let's look at some of the things that distinctively green in *Akira* (Figs. 11, 12).

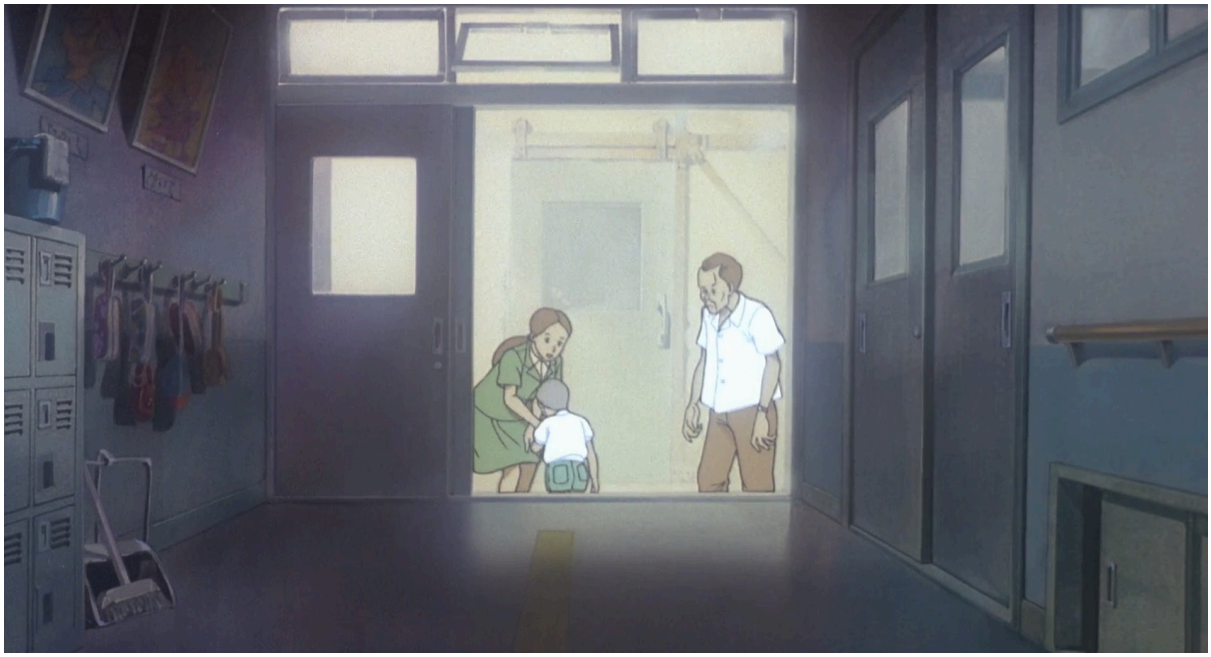

Figure 11: Dreams; 35:32.

Figure 11 is a terrific scene captured from a feverish dream Tetsuo has after suffering from a seizure induced by his exposure to the supernatural powers. Notice the only two green entities in this frame: the young child that is Tetsuo, and his caring teacher. Tetsuo, a brooding teenager now, is reminiscing about his childhood, a time where he "mattered" to those around him, a time far away from the mess of Neo-Tokyo's ruthless gang wars and more importantly, a time where the supernatural entity hadn't trapped him. Even in Figure 12, green is used to signify the "pre-corruption" Tetsuo: a rational, caring human being. However, just a couple scenes later, these same clothes acquire a different color, in Figure 13, when the "post-corruption" Tetsuo shows us his powers in a destructive rampage. Otomo seems to be reserving green for the "good".

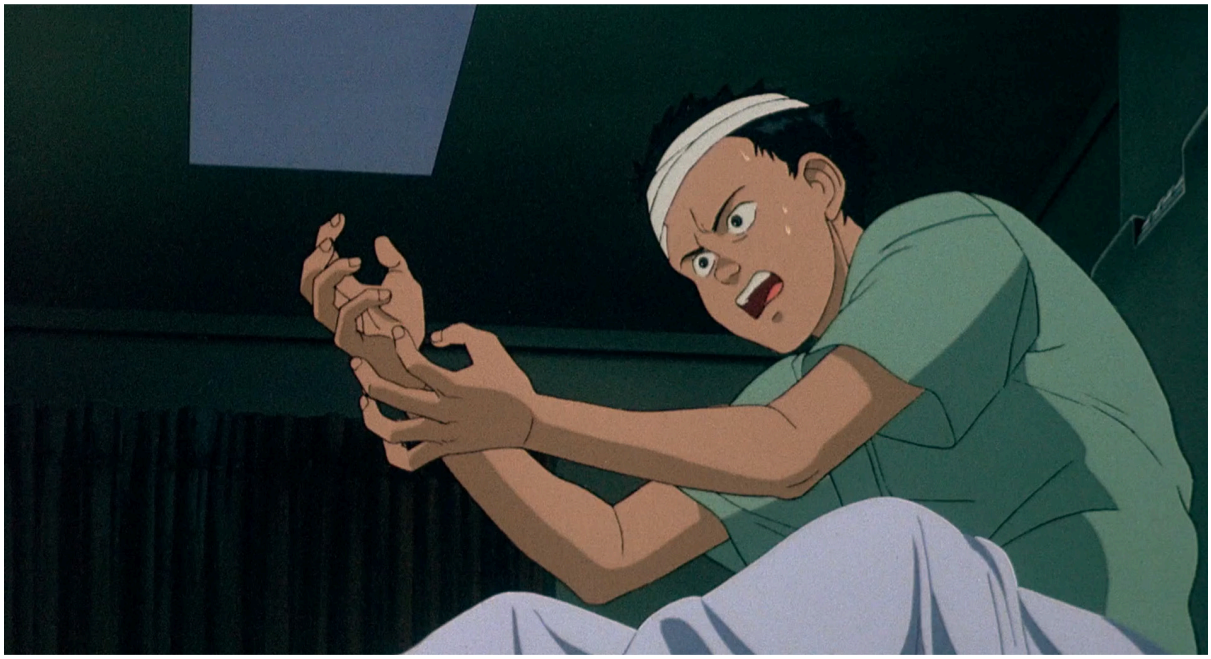

Figure 12: Pre-corruption Tetsuo; 36:21.

Figure 13: Same clothes, different man; 1:01:03.

In fact, when you notice this, all other uses of green start making sense. While there are too many to individually comment on (for instance, Figs. 14 and 15), I will make remark on another major use: the children. The children have cyan/green skin tones (Figs. 16, 17). While, in the beginning of the film this skin tone is used for its "shock value" as the audience looks at a scary, alien child destroy the city of Neo-Tokyo, in what appears to be something akin to Batman's origin story. As we later discover, though, this is just a subtle hint that these children are the "team" we will eventually root for.

Figure 14: The innards of the bar are red, while the outside world is a shade of green; 2:59.

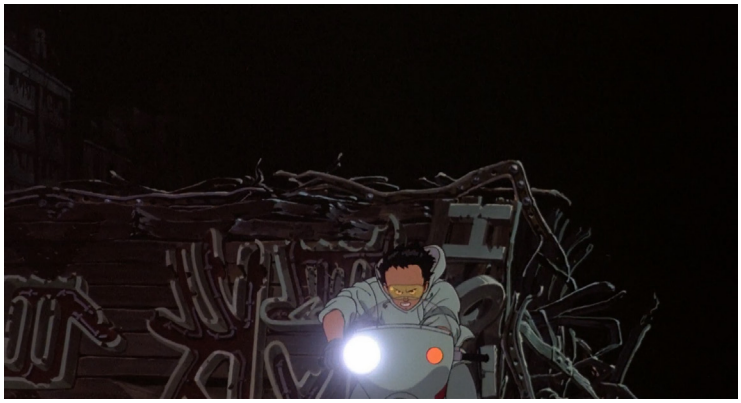

Figure 15: Tetsuo is draped in green during the first bike chase (before he has encountered the child); 12:42.

Figure 16: The children; 1:00:13.

Figure 17: Alien; 9:46.

Animation, and cel-drawing in particular, allows storytellers to infuse cues into the very foundations of environments, and Otomo and the team working on *Akira* clearly knew how to use colors to signal crumbs of information into their audiences' mind.

Negatives: establishing a dystopia

Establishing a dystopic setting is a rather non-trivial task, but *Akira* manages to establish the city of Neo-Tokyo as a post-apocalyptic metropolis rather quickly and smoothly. Director Katsuhiro Otomo cleverly starts the film with a bike chase, using the chase to weave a montage of cityscapes (such as Fig. 18) into plot progression. In all the sweeping hand-drawn shots, however, the color green is quite noticeably missing. Truly, the lack of green here is really a lack of greenery. There is nothing natural about the sprawling futuristic metropolis that is Neo-Tokyo. This has the effect of instilling an odd sense of unease, of unfamiliarity, in the viewers' minds. And of course, this city is at sharp contrast with the Tokyo after the 'singularity' event at the end of the film, where we see water flood into Tokyo, and sun rays hit the city on this new dawn. A dystopia has been terraformed.[4]

Figure 18: Neo-Tokyo; 3:58.

It is notable, however, that lack of green is not a defining feature of all dystopian settings. While *Akira* uses it beautifully to produce a sense of cyberpunk urbanism, there are other films such as the *Matrix* trilogy (1999–2003; Elvy, 2020), which tint everything in green, and still portray dystopias in a captivating manner. As director Katsuhiro Otomo said in an interview[5], he wanted [Neo-]Tokyo itself to be a major character in *Akira*. In Otomo's world, the transition between a futuristic metropolis and a flooded post-apocalyptic city would be Tokyo's character arc. Treating a city as a character allows *Akira* to do something special: as a viewer, it feels as if we can assign emotion and texture to a city, it feels intuitive.

[4] Nature is healing, were we the virus?

[5] https://www.youtube.com/watch?v=xf0WjeE6eyM

GHOST IN THE SHELL: ROTOSCOPING

Ghost in the Shell is a masterpiece of a philosophical text framed as a surreal exploration of identity and consciousness. To reduce it to mere graphic visualizations[6] is somewhat reductive to say the least, but nonetheless, these graphics (Figs. 19–24) can help us observe some interesting aspects of this retro-futuristic creepy film. As director Mamoru Oshii noted in an interview, *Ghost in the Shell* has extremely complicated origins in its manga, and he thought his job, as a director, was to condense the essence of the original universe into 80 minutes of reel.[7] My aim with the single page of visualizations was to condense these 80 minutes of reel into 1 page.

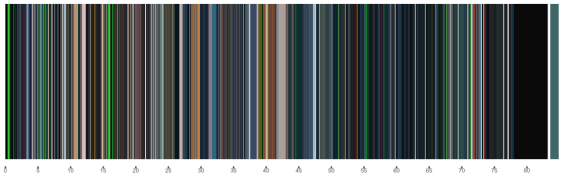

Figure 19: Barcode (finesse = 1 s).

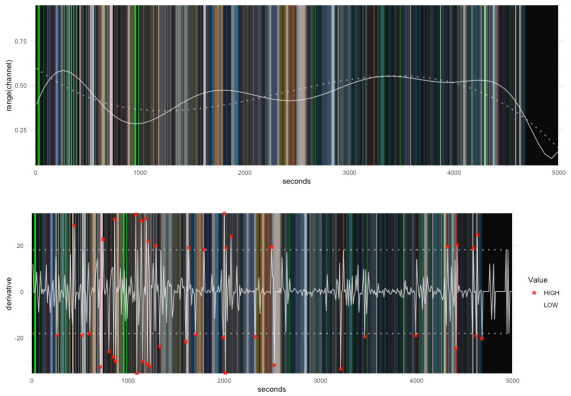

Figure 20: Hue channel (top) and its derivative (bottom).

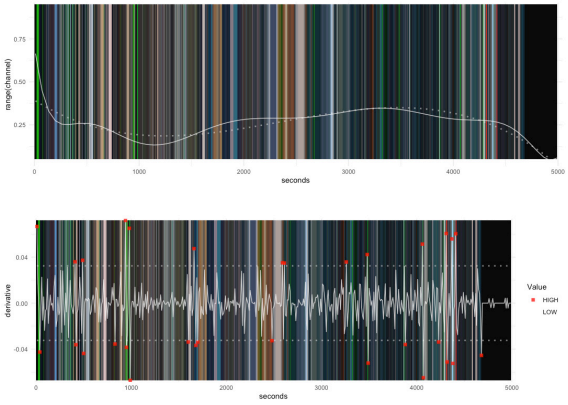

Figure 21: Saturation channel (top) and its derivative (bottom).

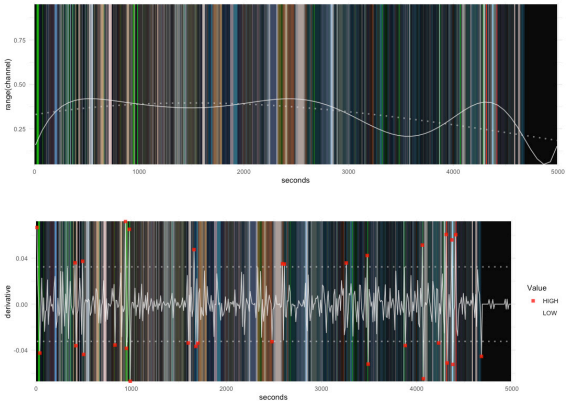

Figure 22: Luminance channel (top) and its derivative (bottom).

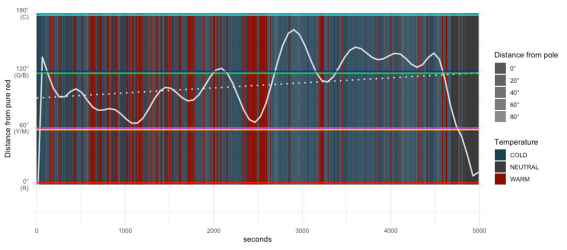

Figure 23: Color temperature analysis. The analysis shows two distinct phases in the film.

[6] These visualizations also emphasize the ideas described in the discussion about *Akira* above. *Ghost in the Shell* is a lot darker than *Akira*. Yet, *Ghost in the Shell*'s scenes of darkness are punctuated by the team using a green and blue color palette.

[7] "It was a very difficult manga. After he told me to do it, I had to re-read it 20 more times. It's a very difficult, complicated manga. So, I thought my job as a director is to make this complicated book into a simple movie." (Mamoru Oshii, TIFF interview: https://www.youtube.com/watch?v=oM-rVr7Knzw

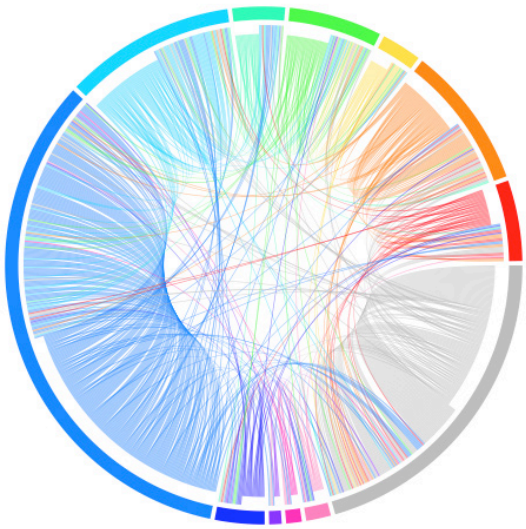

Figure 24: Chord diagram.

Dermatology

For starters, it's quite evident from the movie barcode that the film is really about humanity. The film is full of close-up shots of faces, of the "shells" we are trapped in, and this focus is even more evident in the movie barcode, which looks akin to a skin tone chart. Even when the frames themselves focus a lot on close-up shots of "shells", *Ghost in the Shell* is in part a philosophical exploration of the inevitable second order effects of the societal disregard for human bodies. There are many scenes where we see nude shots of 'puppets' who seem oblivious to their surroundings (Figs. 25–27). In any other anime film, we might be quick to dismiss these suggestive, voyeuristic shots as "fan service", but *Ghost in the Shell* uses these to express something deeper. When bodies are purposeless shells, what does it even mean to sexualize them? What happens to our primitive social structures that use reproduction and voyeurism as a means of establishing society?

Another, more subtle second order effect resolves itself in the actions of soldiers and criminals. Action sequences in *Ghost in the Shell* are accompanied with gory shattering of the shells of the characters involved (Figs. 28, 29). As Major remarks after swimming in the sea (about 30 minutes into the film), when prosthetic bodies grant us this liberty to show a complete disregard for our physical wellbeing, how does one even feel "fear, anxiety, isolation, and darkness", the feelings that are the essence of "hope"? In a poetic way, the climax of the film is a subtle consolidation of these two ideas. We see Major, stripped of her clothes, completely devour her "shell" in her manic quest to understand the "ghost" inside it (Fig. 30).

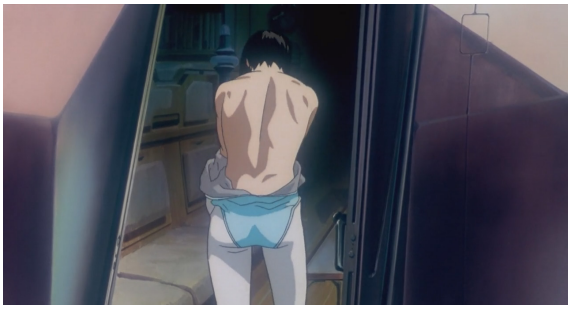

Figure 25: Motoko, completely oblivious to Batou's presence; 29:36.

Figure 26: Dress code? 03:50.

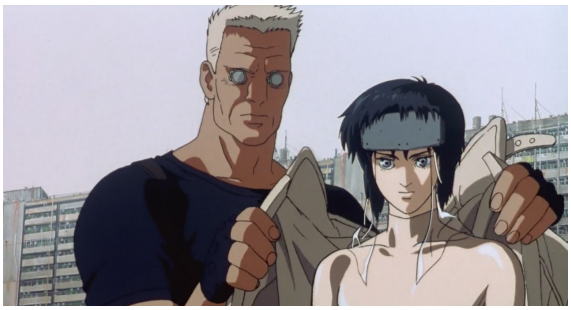

Figure 27: A human reminder; 24:03.

Figure 28: Defaced; 1:13:22.

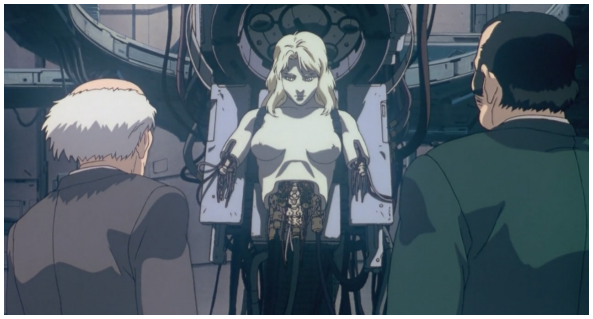

Figure 29: Innards; 47:49.

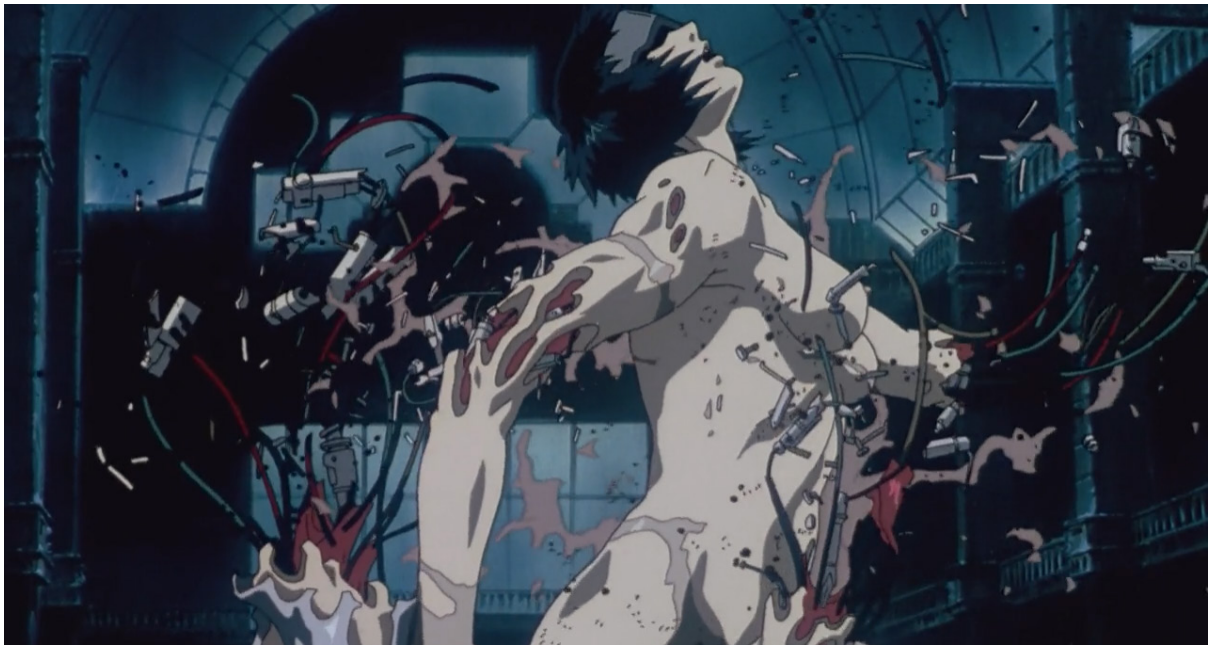

Figure 30: Shedding the shell; 1:05:10.

Let's take a look at the temperature analysis plot of the film *Ghost in the Shell* (Fig. 23). Looking at this graph, it seems there is a striking change in tone at around 40 minutes into the movie. While the first half of the film seems to oscillate between cold and warm colors, the second half of the film has a consistent cold tone to it. In plot, this change seems to occur around the scene where we first learn of the Puppet Master's escape. This change serves a subtle narrative purpose: the first half of the film focuses on the age-old existential questions of the Ship of Theusus[8] and René Descarte's *Cogito Ergo Sum*[9], whereas the second half of the film focuses more on exposition and thriller action.

Notably, this change of pacing is also marked by shots that have an overwhelmingly tan/melanin color scheme, as shown by the movie barcode at about 42 minutes. These are actually two successive shots, the first being a close up of Batou in his characteristic tan jacket, towering next to the Major, and the other of Section 9 Security Chief's lush oak offices, which juxtaposes the semi-human foreground characters with an organic background.

The horror of Socrates

From the perspective of an analysis, the first half of *Ghost in the Shell* is quite unique. While we learn about this world, we encounter the questions Motoko and the others have struggled to deal with, and now we the audience are forced to fence with them in our own lives. Even our very first intimate introduction to Motoko portrays her as a silhouette of a human being, a servant for the background city (Fig. 31). There is something starkly inhuman about this Frankenstein's monster's body that just gets up and leaves for work in sync with the unsettling retro-dystopic background music. From the very beginning, the audience is curious about the true nature of the identity of Major Motoko Kusanagi.

[8] https://en.wikipedia.org/wiki/Ship_of_Theseus

[9] https://en.wikipedia.org/wiki/Cogito,_ergo_sum

Figure 31: A ghost (Motoko) in the shell (Section 9); 07:42.

The most iconic scene in *Ghost in the Shell*, however, is the montage of cityscapes shown about 33 minutes into the film. In a 3 minutes 20 seconds interlude, we see 35 different shots of the city from the perspective of Major. While this has been picked over for its excruciating details by numerous reviewers[10,11], I would like to focus on the "uncanny" interpretation of these visuals. To do so, however, we must rewind to the preceding scene (Fig. 32).

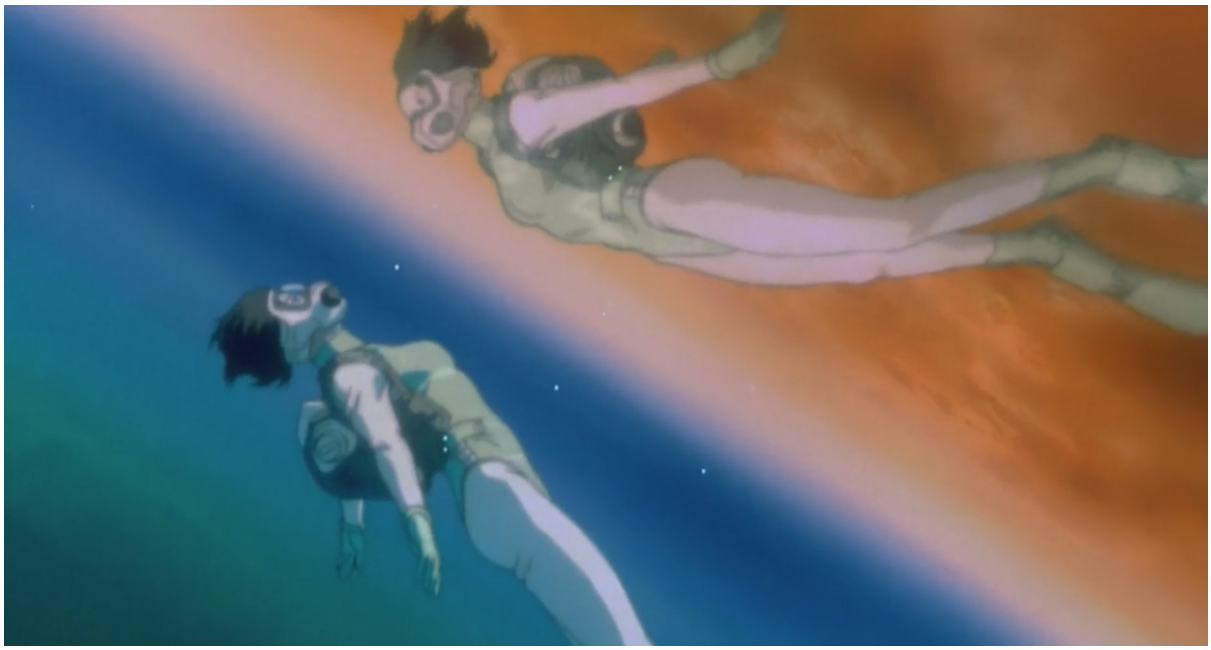

Figure 32: Bubbling to the surface; 28:28.

[10] https://www.youtube.com/watch?v=ARTLckN9e7I

[11] https://echo-from-the-void.tumblr.com/post/180722199329/the-montage-sequence-in-gits

We see Motoko and Batou reflect on swimming, and this is the first time where we explicitly see them bring up the philosophical questions that have plagued humanity for centuries. However, the most striking interrogation comes towards the end of this scene. We (and the characters) hear an ominous, anonymous voice questioning, "Now it's like we're looking through a mirror. And what we see is a dim image." As if searching for the source of this voice, Motoko looks around, until she stops her gaze right at the camera (Fig. 33). Are we the voice?

The camera quickly cuts to the aforementioned montage of cityscapes, and all the audience can do now is question their own humanity. There are extremely suggestive shots of what director Momoru Oshii wants us to think about, from (Figs. 34 vs 35, to 36 and 37), but the most chilling shot is the one of Motoko and another copy of her shell staring at each other across a window in Figure 37 (what she sees is, perhaps, "a dim image"?). If Motoko's shell is just a cheap and random piece of trash from a black market, what even makes her her?

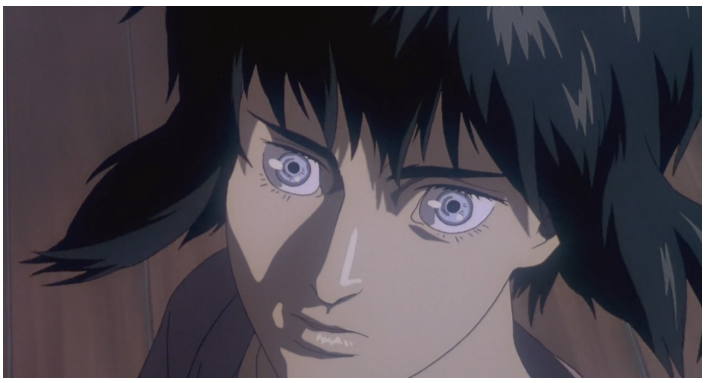

Figure 33: 33:00.

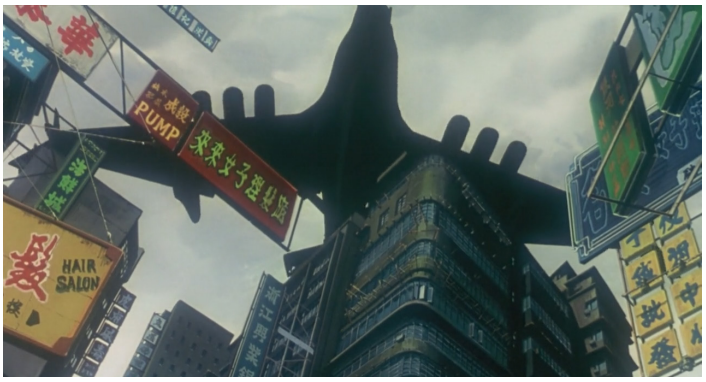

Figure 34: A manmade plane? 33:08.

Figure 35: …or a fish? 33:09.

Figure 36: Trash; 33:33.

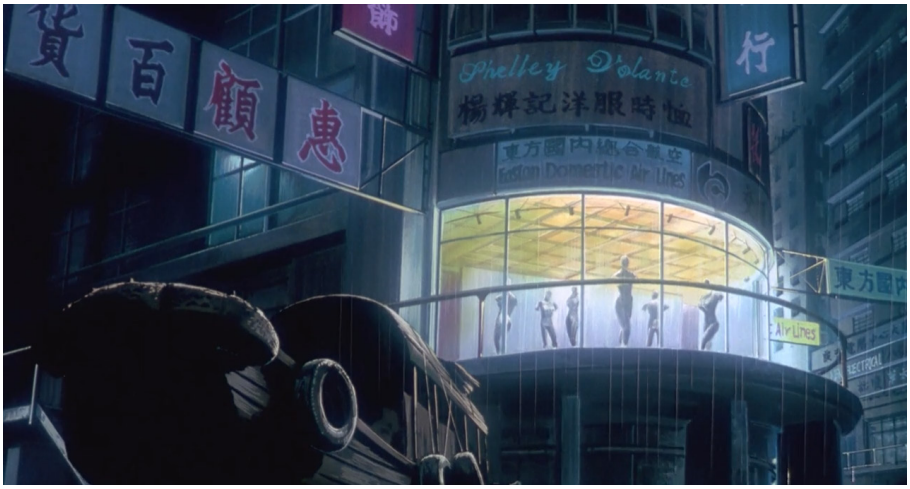

Figure 37: Lifeless mannequin shells; 36:06.

Figure 38: 33:51 (left) vs 33:56 (right).

The solicitude of Heimat

Heimat (from the German) functions as the close environment that is understandable and transparent, as a frame, in which behavioral expectations are met, in which reasonable, expectable actions are possible – in contrast to foreignness and alienation, as a sector of appropriation, of active saturation, of reliability.

The English language, unfortunately, has no equivalent for the word Heimat, but it is perhaps the only word appropriate for the feelings of Major Motoko. Motoko is facing a deep identity crisis, and starkly lacks any sense of Heimat in her life. Motoko does everything in her power to protect and serve the citizens of Section 9, but in exchange, the city should owe her a sense of belonging. Motoko, however, feels robbed of this primal feeling, and this is what defines her soul-searching journey.

It is quite fitting then, that the movie ends in an abandoned museum, with Motoko getting shot up by the police force and being left to die. The entire second phase of the film is colored with a dark, gothic color scheme shrouded in rain. While the environment itself is a portrayal of melancholic feelings of identity, the foreground of the second half of the film is continually filled with action. We, the audience, are still coming to terms with the emotions of the characters, and more importantly, we are still grokking the philosophical questions raised by the first half of the film. The second half of Ghost in the Shell balances exposition, teaching us a lot more about the characters and their motifs, with thriller action. While Motoko herself has interesting character developments, Batou probably has the most interesting character arc in this half of the film. Throughout the film, Batou has served as our human representative in this confusing retro-futuristic world, and now, we see how much he truly cares about Major. He acts cautiously, but he still encourages Motoko to take the lead and find the answers to her questions. Whether it is the boat scene or the aftermath of the truck driver, we see Batou as Major's guardian angel, and even at the end, Batou is the one who saves Motoko at the museum. Even director Mamoru Oshii subtly nods at this interpretation, literally showing Batou's arm as Major's guardian angel in successive shots (Figs. 39, 40).

Figure 39: A guardian angel. You can spot the outline of Batou's arm in the top of the frame; 1:13:21.

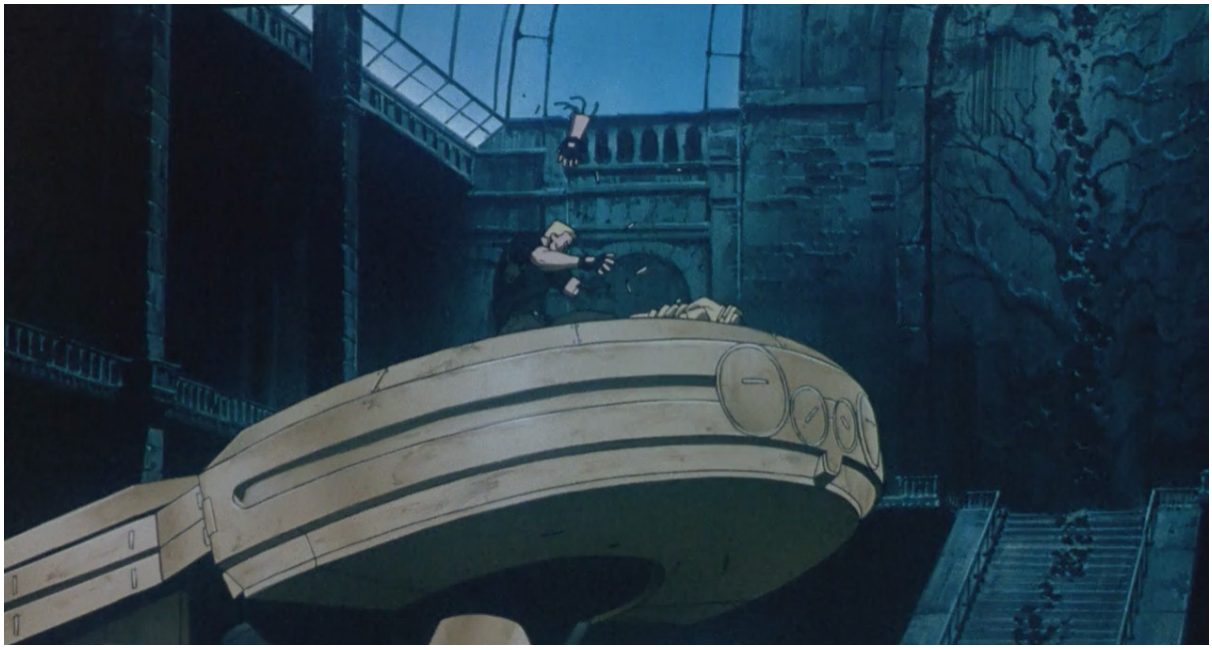

Figure 40: The shot right after Figure 39; 1:13:25.

Since it holds a lot of cryptic meanings, I would also like to explore the dialogue of the very last scene:

> **Major:** Is this your safe house?
>
> **Batou:** Yep. You're the first person to ever come here. — And you're welcome to stay as long as you like.
>
> Major: Thanks, but I am going.
>
> ⋮
>
> **Major:** "When I was a child, my speech was that of a child. My feelings and thoughts too were those of a child. Now that I have become a man, I part with the child-like ways."
>
> ⋮
>
> **Major:** Well, where shall I go? — The net is vast and infinite.

The movie ends (Fig. 41) with Motoko/Puppet Master waking up in Batou's safe haven, where Batou welcomes her and requests her to stay with him. But having merged with the Puppet Master, she is a completely new being, as she acknowledges in her dialogue. She chooses to forego the human bond Batou has offered throughout the film. Now, the only space that can provide her Heimat is the "vast and infinite net".

CONCLUSION

In this paper, I analyzed the films *Akira* and *Ghost in the Shell*. These are both seminal films that have greatly influenced modern horror/thriller/futuristic films and, as a result, they have been picked over by numerous reviewers and analysts. However, my approach to analyzing these films is quite different from the conventional methods. I used data analysis tools to make observations about "macro" trends in the films and rationalized these observations using scenes and clips. I hope my project inspires audiences to reconsider how they've looked at *Akira* and *Ghost in the Shell* and, perhaps, even reimagine the entire methodology of film analyses in the process. With computers as our "bicycles for the mind", there is definitely a lot left to be done in the film department, and I hope that this analysis functions as a glimpse of that potential.

Figure 41: 1:17:51.

REFERENCES

Elvy, C. (2020) Why Matrix is so green on Netflix and how to watch with original color. Screen Rant. Available from: https://screenrant.com/matrix-green-color-change-netflix-original/ (Date of access: 30/Apr/2020).

Methods and credits

All the visualizations were made using a combination of Python, Julia and R (in particular, using the chroma R package).

The screen captures used here were taken from home video formats of Akira (Tokyo Movie Shinsha, 1988) and Ghost in the Shell (Production I.G, Bandai Visual, Manga Entertainment, 1995).

About the author

Nalin Bhardwaj is a math and literature student at University of California San Diego. He primarily works in the tech industry, with research interests in algorithms and data structures, but he often writes about interesting art and literature on his website, https://nibnalin.me

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Beyond Blue: a game backed by real science

Interview with Mandy Joye

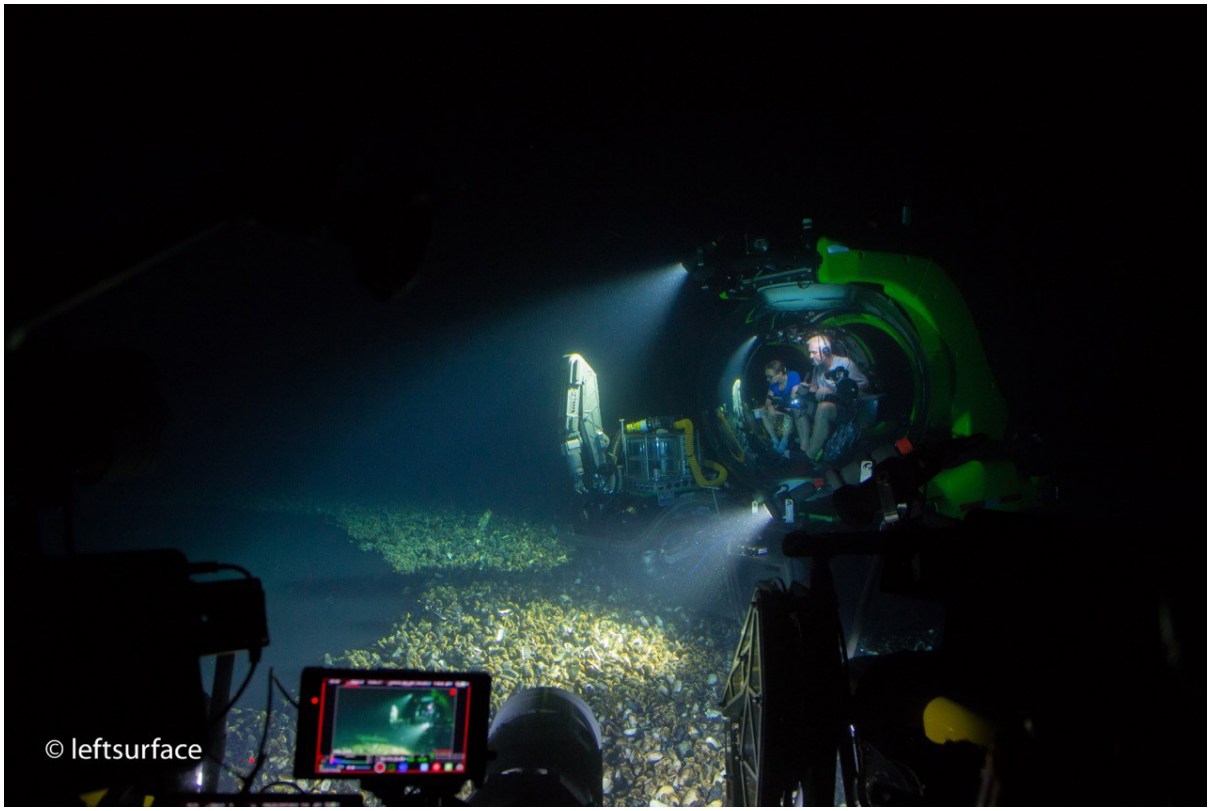
Beyond Blue is a new multiplatform indie game by E-Line Media.[1] The game is set in the near future, and you explore the ocean as part of a new research team. During your dives, you can see and interact with the marine fauna. One of the most interesting things about *Beyond Blue* is that the team at E-Line partnered with BBC Studios and OceanX Media for creating the game. And even better than that, they had the support of actual scientists to give them expert advice about everything that goes on in the sea.

We reached out to one of these scientists, Dr. Samantha "Mandy" Joye from the University of Georgia (USA), to understand her role during game development and to get to know a little bit about the actual science that is backing *Beyond Blue*.

You were one of the experts who gave advice to the game designers of the recently released *Beyond Blue*. How exactly did that partnership came about?

I served as a science advisor to the BBC team during development and shooting of *Blue Planet II*. I was connected to the E-Line team through my *BP II* contacts. When I met the members of the E-Line team and heard their vision for the game, I knew that I wanted to help in any way I could. Serving as science advisor to the team was a rewarding and enriching experience.

[1] The same studio responsible for the award-winning *Never Alone* (*Kisima Inŋitchuŋa*) of 2014.



Inside DeepRover during the BBC *Blue Planet II* filming expedition (at the brine pool).

Before we move on to talk more about your time with *Beyond Blue*, would you mind explaining a little bit of your research to our readers?

I am oceanographer. By training I am a microbiologist and a geochemist, so my work is interdisciplinary at its core. I work a lot in deep sea extreme environments like hydrothermal vents and methane seeps, but we also work in the pelagic ocean. I study the ocean "top to bottom" – I am fascinated by connectivity and complexity and a lot of our work assesses benthic-pelagic[2] coupling and exchanges. Overall, my work strives to understand how ocean ecosystems respond to perturbation through adaptation and resilience.

How did your experience in Marine Sciences was translated into *Beyond Blue*? What kind of advice were you giving?

A: My role involved sharing my knowledge of the ocean – particularly the deep ocean – with the E-line team. I helped ideate gameplay scenarios and assured that scenarios are based firmly in known science. We also ideated technology that we felt was needed today – "in demand" – and that could be developed in the next 10–15 years.

We can see a good deal of science was weaved into *Beyond Blue*. What do you think is the game's greatest accomplishment in this regard? And what theme(s) do you think should have been explored further?

I love that science is central to the game! The gameplay and flow were developed strategically, and there are several jumping off points for development of future gaming scenarios. I don't look at the game as one part being more developed than another – I see this as a way to allow seamless downstream production.

[2] The term "pelagic" refers to the water column, the home of swimming and floating organisms. The term "benthic", on the other hand, refers to the bottom of the ocean, where organisms crawl along, burrow into, or attach themselves to the substrate.

In the game, the player can dive and experience the ocean's wildlife up close. You've been in submersibles and must have experienced amazing encounters with all sorts of fantastic and weird creatures. Could you describe what's that like? What was the most memorable encounter you had in the depths?

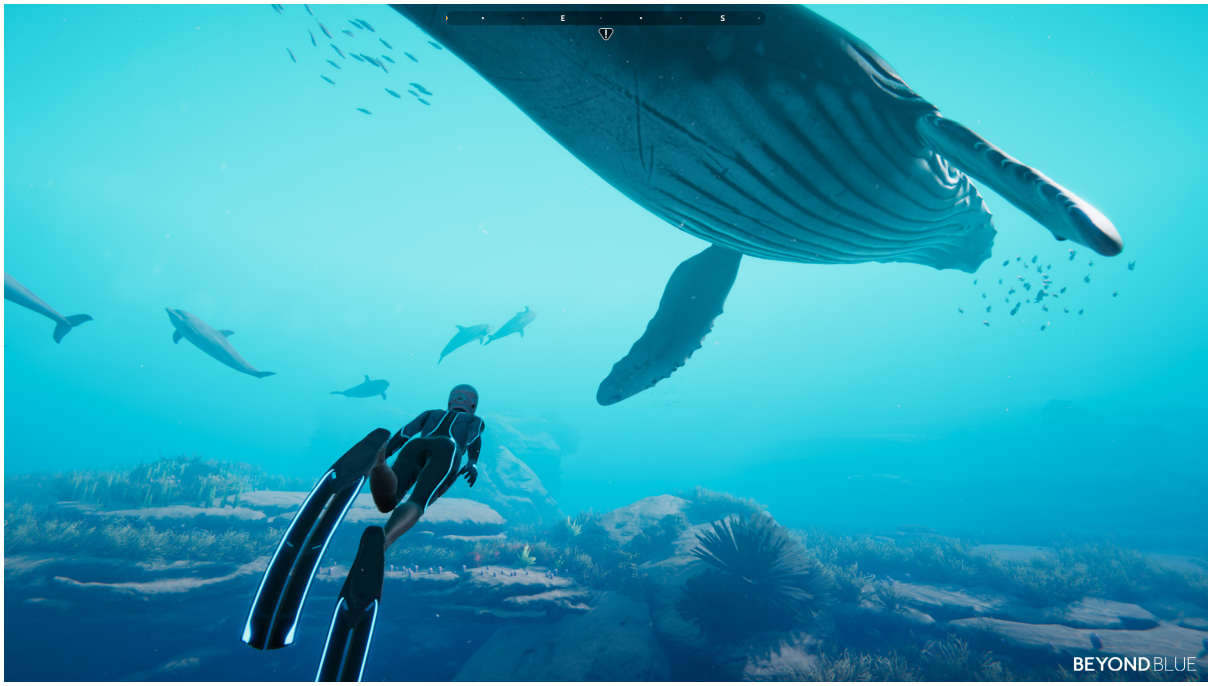
I've had incredible 'up-close-and-personal' experiences with animals from inside a submersible and while scuba diving. One of the most remarkable animals I've ever seen from inside a sub was a 6-meters-plus sixgill shark (*Hexanchus griseus*). I saw this animal when I was doing my first dive in the sphere – as lead scientists on a dive – of the Johnson Sea Link submersible. We were diving at a methane seep in the Gulf of Mexico and were checking on some instruments we had deployed at the seabed. One instrument had a large radar reflector attached to it (so we could find it) and the reflector was about 1 meter across. The shark was enormous! I still remember what I said – "holy cow!" – but what I did amazes me. I kept the camera on the shark as it swam past us, giving us the side eye. It swam around us – past the radar reflector – and I got the shot and we were able to determine how long it was (about 22 feet / 6.7 m). Biggest shark I've seen from that close (probably not more than 10 feet / 3 m away from us). She came back several times during the dive to make sure we knew we were in her territory but she was not close enough to get shot that good!

Scuba diving I've seen all kinds of fish, critters, and mammals. I love whales, of course, but once I ended up swimming with a group of green sea turtles off the north shore of Oahu once and it was magical. One of the larger turtles was fascinated (I guess?) by my ponytail and kept grabbing it playfully. For probably half the dive it swam with me. Others kept their distance but not this one. It was quite an experience to have this beautiful animal swim right beside me – watching me as much as I watched it – for almost half an hour. It was quite a memorable dive.

***Beyond Blue* focuses heavily on whales, but they represent just a tiny fraction of the ocean's biota.[3] Do you think that's justified? Or has the "save the whales" banner been overused by now?**

Yes, it is justified because whales play a vital – truly essential – role in the ocean. We

[3] There are circa 90 species of cetaceans worldwide (counting whales, dolphins and porpoises), but over 200,000 animal species in the sea. Cetaceans make up less than 0.0005% of the marine fauna.



need to "save the whales" as much for ourselves as for them. Why are whales a tiny fraction of marine biota? Because we've fished them out and now, we've set our ship channels in their migration paths leading to ship strikes that further decimate endangered populations. I have been working with an amazing modeler, Brock Woodson[4], and he has led the work that discovered that much of how we think about marine food webs[5] – the classic idea of a triangular trophic pyramid with energy going from the bottom to the top needs revision and rethinking. Energy can flow very efficiently from low trophic levels to whales, directly building a lot of biomass. Whales and other megafauna were SO much more abundant in the past and by restoring whales, we could go a long way towards reviving ocean sustainability.

Some insidious threats were shown in *Beyond Blue*, from bits of plastic the player finds on the seafloor to the terrifying deep-sea mining equipment. Among the many threats our oceans are facing, which one is the most pressing?

In my opinion, the most pressing single stressor on the ocean is climate change – climate change is literally destabilizing the physical stratification and circulation of the ocean. Changes in ocean stratification and circulation have far reaching consequences for ocean biota and ocean function and all of the consequences are bad. That's not to say that plastics and mining are not issues to be concerned about. They are critical issues and I worry about both. I just worry about the impacts of climate change more.

So, how do you feel about *Beyond Blue* now that's out? Do you think it can give players a deeper appreciation for our oceans and all the life in it?

Yes! The game does a remarkable job of providing players with an incredible experience that is science-based yet fun and fascinating, and even motivational.

Do you think *Beyond Blue* has potential

[4] Dr. Woodson is also a researcher at University of Georgia, USA.

[5] Woodson, C.B.; Schramski, J.R.; Joye, S.B. (2018) A unifying theory for top-heavy ecosystem structure in the ocean. Nature Communications 9: 23.

to be used in classrooms? As a teaching aid or, perhaps, as a 'mandatory reading'.

Yes. I've actually written proposals with the E-Line team to do this very thing and I hope we have the chance to develop education content around the game.

Is there some take-home message you would like the players to get?

The ocean is fragile.

In the ocean, everything is interconnected at some level.

Science is hard (!) but fun and rewarding.

Find your passion in life and pursue it with vigor.

Supposing the game picked the interest of a player about life in the oceans, could you recommend them some references about it?

The BBC *Blue Planet II* series is simply FANTASTIC!! There is a book too.[6]

Rachel Carson's The Sea Around Us is a must read for everyone interested in the ocean. I love Susan Casey's book *Voices in the Ocean* (about dolphins). I just reread it recently and it was even better the second time. *The Extreme Life of the Sea* by Steve Palumbi is also very good. *Blue Hope* is a photography-based book by Sylvia Earle and I love it (as do my kids).

And now the big question: do you play video games?

No, I don't. I would be an addict if I did, because I'm extremely competitive. So, I read instead.

About the interviewee

Dr. **Samantha Joye** is a microbiologist, an educator, a deep ocean explorer, and a vocal ocean and environmental advocate. Joye is a Regents' Professor and also holds the Athletic Association Professorship in Arts and Sciences at the University of Georgia; she is a Professor in the Department of Marine Sciences. She is an expert in microbial geochemistry, focusing on understanding elemental dynamics, particularly in pelagic and deep ocean environments. Her work is highly interdisciplinary, bridging the fields of biology, analytical chemistry, and geology. Her research is widely published in leading scientific journals, and she is regularly called upon by national and international scientific and policy agencies for expert commentary. Her research has been supported by substantial, multi-year research grants from the National Science Foundation, the Environmental Protection Agency, the Gulf of Mexico Research Initiative, the Department of Interior, and the National Oceanic and Atmospheric Administration, among others. She is a Fellow of the American Association for the Advancement of Science, the Association for the Sciences of Limnology and Oceanography, the American Geophysical Union, the American Academy of Microbiology, and The Explorers Club.

Mandy is a huge sci-fi nerd and having a sci-fi book use something she played a part in discovering in its plot is pretty cool. Have you read *The Swarm* by Frank Schätzing? Well, this book describes a worm that lives on methane hydrates in the deep sea – methane ice worms. Mandy was on the expedition where these ice worms – yes, they are real! – were discovered and is a co-author on the paper reporting the discovery.[7]

[6] Honeyborne, J. & Brownlow, M. (2018) Blue Planet II: A New World of Hidden Depths. BBC Books, London.

[7] Fisher, C.R.; MacDonald, I.R.; Sassen, R.; Young, C.M.; Macko, S.A.; Hourdez, S.; Carney, R.S.; Joye, S.B.; McMullin, E. (2000) Methane ice worms: *Hesiocaeca methanicola* colonizing fossil fuel reserves. Naturwissenschaften 87: 184–187.

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The biological basis of Marvel Comics mutants

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"Feared and hated by a world they have sworn to protect" is the catchphrase always present in nearly all comics of Marvel's mutants, the X-Men. This phrase was coined by Stan Lee, the co-creator of the X-Men together with Jack Kirby. A popular proverb states that "we fear what we do not understand" and this is probably the case with the mutants within Marvel's comic book universe. Therefore, the question is: can we understand Marvel's mutants? That is the main aim of this essay.

The word 'mutant' is often found in science fiction literature, television and movies. The mutant condition is not an invention of these arts and media. In the decade of 1960, Stan Lee (hallmark comic book writer of Marvel Comics, born as Stanley Lieber) was in his peak of creativity (e.g., *Fantastic Four, Spider-Man, Hulk, Thor, Iron Man, Ant-Man* are inventions from those years) and he was searching for new and different ideas for the origin of his characters' superhuman powers. 'Cosmic rays', 'nuclear radiation', 'radioactive animal bites', were some of the causes of these origins. Stan Lee and Jack Kirby shaped a new excuse: instead of giving to their characters an event that causes their powers, they could create characters born with those powers. They could not escape from the radioactive influence of the Nuclear Age (the decades of 1940 and 1950), but they chose a new way to make use of it. In this new concept, the radioactive waste of nuclear tests generates changes in human offspring, and mutants were the consequence (Accorsi & Accorsi, 1994; Clemente, 2000; Kakalios, 2005).

Beyond Stan Lee and Jack Kirby, this is the same concept used in the Japanese *Godzilla* films of previous years. Thus, the word 'mutant' was often used in sci-fi literature of the 1950s to designate human variations with strange superpowers. The term was used a few times during those years in some Atlas (previous name of Marvel Comics editorial during the 1950s) comic books from 1952 to 1963 (for example, in *Tales of Suspense #6*, from 1959). Officially, according to the established cannon, the first time the term 'mutant' was used in the modern sense was in *Amazing Adult Fantasy #14*[1] (July 1962, written by Stan Lee) for Tad Carter, a character with flight and psychic abilities. Then, on late 1963, the first issue of the comic book *The X-Men* was released, and comic books' concept of mutants was born. The X-Men have been one of the most important superhero teams in comic books from their creation until this day (Fig. 1).

The aim of this essay is to take a biological approach to the features of mutants in Marvel Comics, considering their comic book appearances and the biological modern concepts used for describing their features by several comic book authors. From it, an attempt will be made to build a logical proposal for 'mutant' and mutant genetics and biology with a real-world biological basis.

[1] This is the same comic book that presented *Spider-Man* in its next issue.

Figure 1. Hallmark issues in the history of mutants. From left to right (all from Marvel Comics): *The X-Men* #1 (1963), *Giant Size X-Men #1* (1975), *X-Men Vol. 2* #1 (1991), *House of X* #1 (2019).

METHODS

Biological and genetic concepts considered for this review include: cell, mutant, mutation, gen, genotype, phenotype, genome, protein, nucleic acid, genetic code, DNA, among others. All of these terms were considered in their widely accepted and simple meaning, taken from general Biology textbooks. For guidance, the main books used are Alberts et al. (2010), Curtis et al. (2015), and De Robertis et al. (2012).[2]

In Biology, the term mutant refers to an organism with a variation within a genotype (or a particular gene) from the expected wild type. The complete set of genes of a species, the genome, contains all the genes. Each gene is an arbitrary portion of the genome that codifies for a particular protein. As a consequence, these proteins can be translated into a particular trait. Genes (and the complete genome) are stored as nucleic acid molecules (in the case of all living organisms this molecule is DNA, deoxyribonucleic acid). The DNA molecule contains monomeric units, the nucleotides, and shape the genetic information. Changes and errors in the genetic information between parents and offspring could be the origin of mutations. These changes and errors could be generated during duplication, transcription, translation or other internal processes of cells. Also, external events can produce mutations, for example exposition to radiation. This incomplete and extremely reduced explanation is the brief basis for the following questions and answers. For the purpose of this essay (and for fun), the biological basis of the comic book universe is considered to be identical to the real-world's biology basis, despite the fictional nature of comic books.

For the purpose of this essay, only comic books are considered. Movies, TV shows, videogames, and other appearances beyond comic books will not be included. The first Marvel comic book taken in account is *The X-Men #1* from 1963 and the last ones are *Powers of X* and *House of X* (both by Jonathan Hickman, 2019). All other Marvel comic books including mutants or information about mutants between these two points was considered. This comprises 56 years of publications scattered in numerous comic book series. The main resources mentioned are the series *Amazing Adventures Vol. 2* (AA), *Astonishing X-Men Vol. 3* (AX3), *Avengers Vol. 3* (A3), *Black Panther Vol. 4* (BP4), *District X* (D), *Excalibur* (E), *Extraordinary X-Men* (EX), *Further Adventures of Cyclops and Phoenix* (FACP), *Fantastic Four Annual* (FFA), *House of M* (HM), *House of X* (HX), *Inhumans Vol. 2* (I2), *New Avengers: Illuminati* (NAI), *New Mutants* (NM), *New X-Men* (NX), *The X-Men* (X), *Uncanny X-Men Vol. 1* (UX1), *Weapon X Vol. 2* (WP2), *What*

[2] A summary of these terms in Spanish can be found in Sabbatino et al. (2020).

If? Vol. 1 (WI1); *Wolverine and the X-Men Vol. 1* (WX1), *Wolverine First Class* (WFC), *X-Factor Vol. 3* (XF3), *X-Force* (F), *X-Men Vol. 2* (X2) and *3* (X3), *X-Men Forever* (Xfor), *X-Men: Messiah Complex* (XMC), *X-Necrosha* (XN), and *Young Avengers* (YA). The abbreviations indicated above, followed by issue number (with '#'), are used from this point onward as references to these resources.

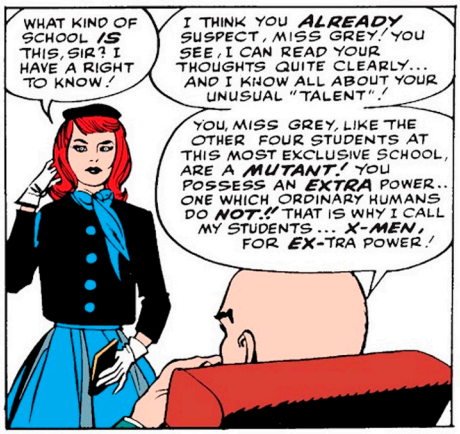

Figure 2. Charles Xavier explains to a young Jean Grey what is a 'mutant' for the first time. From *The X-Men* #1 (X#1: p. 8; Marvel Comics).

DISCUSSION

Definition of 'mutant' in Marvel comics

On the very first issue of *The X-Men* (X #1) (Fig. 2), Professor Charles Xavier explained to a young Jean Grey the meaning of 'mutant'. He said "you (…) are a mutant! You possess an extra power… one which ordinary humans do not!". In other words, mutant is a term used for designating beings with superpowers that regular humans do not possess. But this definition is not clear, because there are many others beings with superpowers in that universe that are not called mutants (Captain America, Spider-Man, Hulk, Captain Marvel, etc.). The following issues of *The X-Men* and other comic book series restricted this term to beings born with superpowers. Following that, the term mutant was once again adjusted to include only beings with a particular variant of a gene denominated X-Gene.

Basis of Marvel's mutant genetics

The 'wild type' for the X-Gene can be considered to be the regular humans in the Marvel Universe. This X-Gene constitutes a single locus with phenotype expression (WX1#5) (Fig. 3). Therefore, this gene is expressed by the manifestation within mutants of extraordinary morphological changes and superpowers. However, some mutants do not possess superpowers, as is illustrated by Jazz, a mutant presented in D#2, whose mutation includes just blue-coloured skin. According to this explanation, a unique gene is the cause of very diverse phenotypic mutations including morphological changes (such as extra-arms, horns, unusually-coloured skin, hairy or scaled integuments, presence of wings or tails, among others), psychic powers (telekinesis, telepathy, mind projection, levitation, among others), physical extreme abilities (superhuman strength, increased velocity, enhanced senses, feral behaviour, among others), thermodynamic manipulation (increasing heat, cold or atmospheric factors), etc.

The species *Homo sapiens* has 3.1 billion of nitrogenous base pairs, but only 30% are transcripted and translated to proteins (International Human Genome Sequencing Consortium, 2001, 2019), which means we have near to 23 thousand genes (Salzberg, 2018). With this relatively small number of genes in the species, there are almost four times the amount of proteins. This is possible because a gene can codify for more than one trait. Different mechanisms are implied in this phenomenon. One of them are the transcription factors. These are proteins that act as triggers to codifying chains with successions of genes and proteins, and regulate the expression of particular genes. By activating the expression of some genes, they can change the processing of others.

There are many mechanisms regulating the expression of genes, in different stages of the process of transcription and translation. Transcription factors are themselves codified by other genes. Therefore, it is very plausible to consider that the X-Gene codifies for one or multiple transcription factors with multiple subsidiary codifying chains.

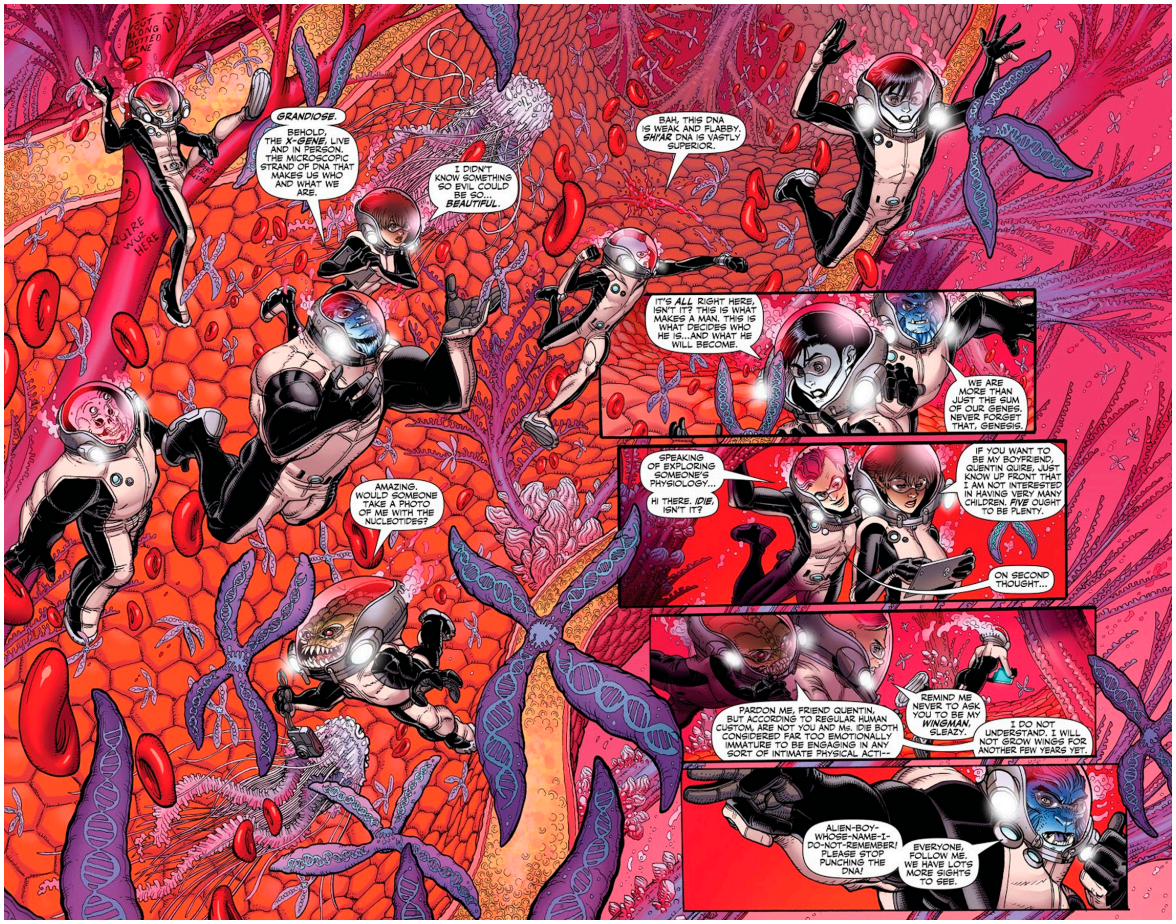

Figure 3. Beast teaches his students about the X-Gene. From *Wolverine and the X-Men* #5 (WX1#5: p. 6; Marvel Comics).

A specific mutation of the expression of a basal transcription factor can "wake up" to a different portion of DNA previously unread. Different pathways of codifying could trigger the development of various features and traits or even more than one trait. Usually, mutations in the Marvel comics are not restricted to a unique trait as is the example of Cyclops (Scott Summers, with optic beams) or Professor X (telepathy). Most of the mutants have a combination of connected traits, as in the examples of Wolverine (James Howlett, with feral senses, claws, healing factor, etc.) or Nightcrawler (Kurt Wagner, with blue fur, prehensile tail, reduced number of fingers and toes, etc.). Also, another name frequently given to X-Gene is X-Factor (F#86; UX1#380).

An intriguing possibility is that transcription factors could be enhancing the codifying of non-codifying known portions of genome (the other 70%) or silenced genes in heterochromatin. The latter was thought to be relatively devoid of genes, but researchers have found them in organisms such as the fruit fly *Drosophila melanogaster* (Yasuhara & Wakimoto, 2006). One of the possible effects of the X-Gene could be to generate epigenetic changes. It is interesting to observe that these changes and their effects are random from individual to individual at some point. These explanations can shed light upon the great variety of mutations recorded and also upon recurrent or similar mutations, such as magnetic mutants (e.g., Polaris [Lorna Dane] and Magneto [Max Eisenhardt a.k.a. Erik Lehnsherr]), winged mutants (e.g., Angel [Warren Worthington III] and Icarus [Joshua Guthrie]), or psychic ones (e.g., Marvel Girl [Jean Grey], Psylocke [Betsy Braddock], Charles Xavier), because the same codifying chains could be expressed in the latter cases. Cases of parental relationships expressing similar mutations (as in the example of Polaris and Magneto) are also included in these explanations.

The emergence of other animals' features in some mutants (such as wings, fur, tails, sharp claws, insect eyes, gills, etc.) could be related to those genes being preserved in human genome without expression, shared with other animals. For example, human beings and chimpanzees share close to 99% of their genomes (King & Wilson, 1975).

An interesting possibility is that the X-Gene could be a homeobox, a 'master-gene', involved in the regulation of patterns of anatomical development in several life forms (Bürglin & Affolter, 2016). Homeobox genes are extremely conserved across different animals, such as the well-known example of the Pax-6 gene (Callaerts et al., 1997).

According to some references (A3#24 and #27, and BP4#17) we know the location of the X-Gene is in the 23rd chromosome (the sex-determining chromosome). The mentioned placement helps to explain the existence of human individuals without mutations born from mutant parents, such as Graydon Creed (son of Sabretooth [Victor Creed] and Mystique [Raven Darkhölme]). According to this assumption, the X-Gene is located in the X chromosome, more precisely in the portion not present in the Y chromosome. Graydon did not inherit the X-Gene from either parent. A more interesting consequence extracted from this example is that the X-Gene is present in at least two alleles, one of them non-active for expression of mutations.

In summary, all mutants are 'mutants' (i.e., different to the 'wild type', the regular humans) due to a unique trait: presence of the X-Gene. This gene codifies for one or more transcription factors, which can be called X-Factors here. These factors trigger different codifying sequences that can be different for each individual. These codifying sequences are the genetic origin of mutant superpowers observed in the Marvel Universe. Codifying sequences mentioned are present in the genome of all regular humans, but the presence of the X-Factor is needed to activate them. Drugs such as 'Mutant Growth Hormone' (or MGH, YA#2 and UX1#490) may be refined from some X-Factors. These drugs give superhuman capacities to non-mutants, and could increase mutation expression in mutants (as is illustrated by Beast's feral changes in AA#11).

A "historical" dataset in the study of mutations mentioned in the comic books is the presentation of Victorian naturalist Nathaniel Essex (a.k.a. Mister Sinister) to the Royal Academy of Sciences of London in the late 19th century about the discovery of 'Essex Factors'. They could be the same X-Factors mentioned above. His investigations were discredited by contemporary colleagues, such as Charles Darwin (FACP #1) (Fig. 4).

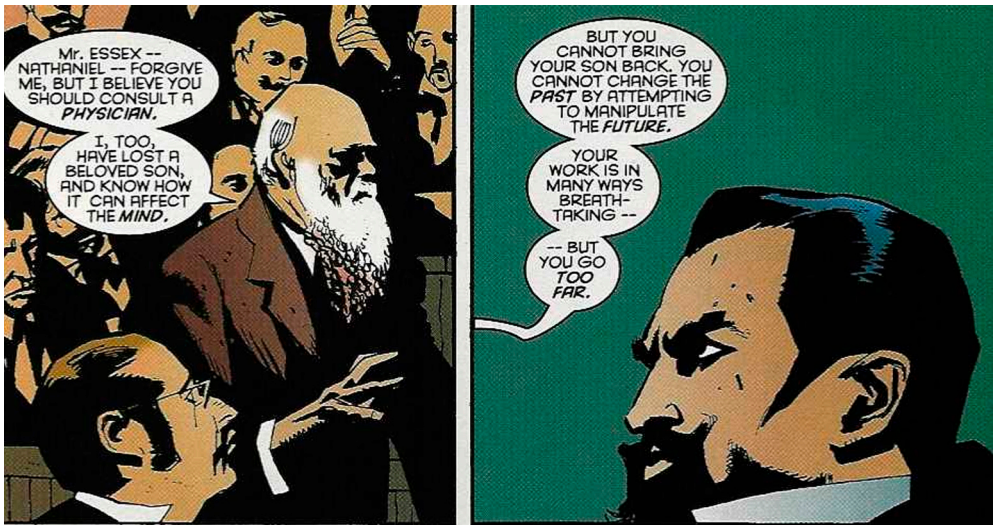

Figure 4. Charles Darwin, as a character from the Marvel Universe, discusses the proposals of Nathaniel Essex. From *Further Adventures of Cyclops and Phoenix* #1 (FACP#1: p. 8; Marvel Comics).

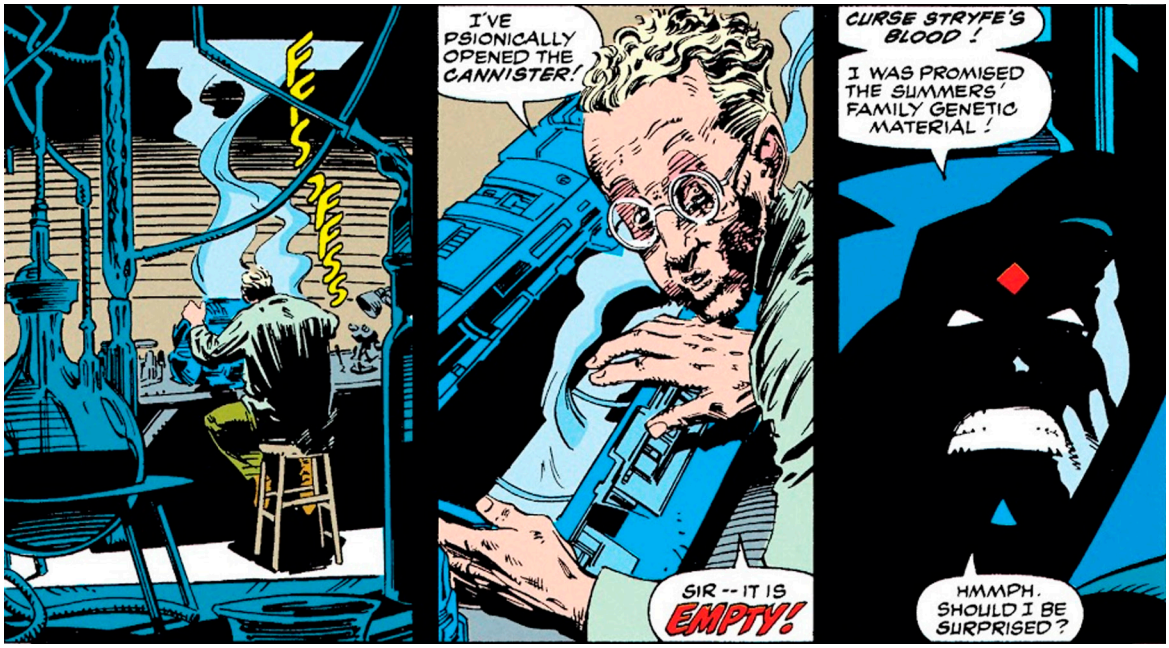

Figure 5. The Legacy Virus is released. From *X-Force* #18 (F#18: p. 23; Marvel Comics).

Diseases and "cures" for the X-Gene

The main disease known for mutants is the Legacy Virus, an artificial virus created and released by the villain Stryfe (F#18) (Fig. 5). This pathogen affected mutants between 1993 and 2001 in all mutant comic book series. Viruses are specific to determinate target cells and gene sequences. The mutant specificity of the Legacy Virus can be explained because this virus only binds to the X-Gene. The only human affected by the Legacy Virus was Moira MacTaggert (E#80), a fact originally explained by a possible new strain of the virus. An alternative explanation was the presence of the inactive allele of the X-Gene in Moira (she was the mother of the mutant Proteus). Recently, it was revealed that Moira is a mutant (HX#2) and so, no explanation of her contagion is needed anymore.

A second plague affected the mutants, the M-Pox (EX#1). This disease is caused by the Terrigen Mist, a substance with religious value to the Inhumans, another superhuman group of the Marvel Universe. Terrigen Mist activates morphological changes on inhumans, with the capacity of developing superhuman powers. In this case, the condition generated by the Terrigen Mist could be different to the Legacy Virus, modifying the X-Gene or transcription factors. No further information has been provided.

Several "cures" to mutations were proposed. The more remarkable was that developed by Dr. Kavita Rao (AX3#1): a serum capable of reversing mutations. The possible mechanisms implied was the suppression of X-Gene codification; or complete modification of it. This could be analogue to the mechanism of CRISPR gene editing technology (Doudna & Charpentier, 2014).

Triggering mutations

Among individuals with the X-Gene, mutations are not expressed from birth. Usually, the mutations are expressed at some point of puberty or adolescence, and related to stress situations. This behaviour is shared with several other genes, such as those related to sexual maturity and secondary sexual characters. On these examples, changes are preceded by the action of some hormones. A possibility is that the activation of the X-Gene is similar and hormone-mediated. Nevertheless, there are some examples of mutants with active mutations from birth (e.g., Nightcrawler and Multiple Man). Evolutionary explanations were provided for these examples (XF3#11),

that implies the retarded expression of mutations was a secondary acquisition of mutants, and the examples mentioned are remnants of these previous stage.

Some mutants expressed at some point secondary mutations (UX1#412; NX#116). Usually, these secondary mutations are activated latter in life, and they are also connected to stress situations. A relation with the increase of human populations and an adaptative origin was proposed for explaining secondary mutations (NX#114). No further information about it is known.

Taxonomy of mutants

In the very first issue of *The X-Men* (X#1), mutants are denominated as *Homo superior*, denoting their difference to regular humans. If the presence of the X-Gene (and its consequences) is a shared condition of all mutants, is this enough to consider mutants as a new species? We should consider that this gene may be a homeobox one. Excluding minimal genotypic differences, and considering important phenotypic ones, we can strongly differentiate mutants. Frequently, comic books refer to mutants as either a distinct species (*Homo superior*, for example in NX#124, Xfor #1, WFC#1, or WP2#28) or a subspecies (*Homo sapiens superior*, for example NX#114 and #118, A3#42). The situation is similar to what occurs with *Homo neanderthalensis* (Pääbo, 2014).

The species name *Homo superior* was erected by Erik Lehnsherr (an alias of Magneto) and first mentioned in 1963 (X#1) (Fig. 6), proposing to indicate the authority over the name as *Homo superior* Lensherr, 1963. A brief systematic appendix about this species is provided further below.

Difference between mutants and other genetics-based superhuman groups

In the Marvel Universe, there are other human "species" differentiated from regular humans. Some of them are the results of experiments of extra-terrestrial beings such as the Celestials; for example, Deviants (*Homo descendus*) and Eternals (*Homo immortalis*). Other known groups are the Atlanteans (*Homo mermanus*), like Namor, and the Inhumans (*Inhomo supremis* or *Homo sapiens inhumanus*).

Figure 6. Magneto mentioned for the first time the name *Homo superior*. From The X-Men #1 (X#1: p. 11; Marvel Comics).

Relationships between Atlanteans and mutants has been discussed (FFA#1; X1#6; NAI#1). Frequently, mutants and inhumans are compared, because they share some characters. Inhumans are a group with superhuman powers resulting from genetic differences to regular humans. They go through a process known as 'terrigenesis' that activate their superpowers. The genetic changes driven by terrigenesis could explain the effects of Terrigen Mist in mutants (M-Pox mentioned above). Apparently, the genetic basis of inhumans powers seems not restricted to a unique gene. This can be the reason why changes incurred in inhumans by terrigenesis frequently are more radical than those observed in mutants (I2#1-12). Terrigen Mist may be an external transcription factor that activates those genes.

In the other main superhero universe of comic books, the DC Universe, an analogue of the X-Gene can be found. It is called 'Metagene', and is present in some humans (known as 'metahumans'). This gene acts as a primary condition for developing superhuman powers. Characteristics of this gene are confusing and poorly explained: in

Figure 7. The Celestials experimented with early hominins and generated, in consequence, mutants and other variations. From *What If…? Vol. 1* #23 (WF1#23: p. 26; Marvel Comics).

some cases it is activated by stress situations and in others by external agents (for example, the Gene-Bomb of the Dominators in the crossover Invasion!). This concept is not very well-developed in DC comic books.

Origin of mutations

In the beginning, Stan Lee considered radiation of nuclear plants as the explanation that gave rise to mutations. In the example of Beast (Hank McCoy), the radioactive influence was located in the job of Hank McCoy's father (Back-up stories of X#49-53). The denomination "Children of the Atom", usually referred to the X-Men, is due to that. Other mutants are also related to radiation of nuclear bombs, as the Japanese mutant Sunfire (Shiro Yoshida) (X#64) and the villain Dragoness (Tamara Kurtz) (NM#94). Nevertheless, the presence of mutants before the "Nuclear Age" of the 20th century contradicts this assumption.

A non-natural origin was proposed for mutants. Celestials (specifically, the Celestial known as Oneg the Prober), a group of extra-terrestrial beings that experimented with life forms across the galaxy, implanted in a group of *Homo erectus* the genetic latent potential to give rise to mutants (WI1#23) (Fig. 7). This experiment could be the prelude to the origin of the X-Gene. From this point, evolution drove the fate of the mutants.

Gradualistic or punctuated origin?

Phyletic gradualism and punctuated equilibrium (Eldregde & Gould, 1972) are two extremes in a continuous model of evolution. The first one claims a uniformly and more gradual accumulation of changes that subsequently generate new species. In contrast, punctuated equilibrium proposed that once a species appears, it becomes stable, showing little evolutionary change; then, an event can trigger a rapid speciation process. The first appearance of the mutants in historical/archaeological record is abrupt (UX1#422), so it is possible to consider their origin as a punctuated process. Further research is needed to clarify this question.

First mutants and mutant lineages

The Celestials' experiments would have happened a million years ago (to public knowledge of mutants in Marvel Universe). Selene is claimed as the first mutant born (XN#1), during the Hyborian Age (17,000 year ago, the age of *Conan the Barbarian*). She was still alive during the times of the Roman Empire and is part of a particular group of immortal mutants, the Externals (F#10). After Selene, the villain Apocalypse (En Sabah Nur, born in Egyptian times), Azazel and the Neyaphem (UX1#422) are recorded. Historical mentions of probable mutants become more frequent from the Middle Age onward. For example, the villain Exodus (Bennet du Paris) lived during

the Crusades. According to Damian Tryp (XF3#11), a transitional human-mutant species (informally known as 'Homo kill-crop') lived around the 12th century. 'Pro-to-mutants' species lived during the Black Plague (X3#30-33). Status and relationships of these lineages are poorly known, but it is very possible that they are transitional or split lineages branching from early mutants. Many other lineages are mentioned between mutants: the Neyaphem, and the angelic Cheyaraphim (UX1#422) (Fig. 8), the lupine mutants (known as Dominant Species, UX1#420), the Neo (X2#99), among others. Origin of mutants seems to be a complex evolutionary story, with more than one simple lineage. Mosaic evolution could better describe the evolutionary trends of the group.

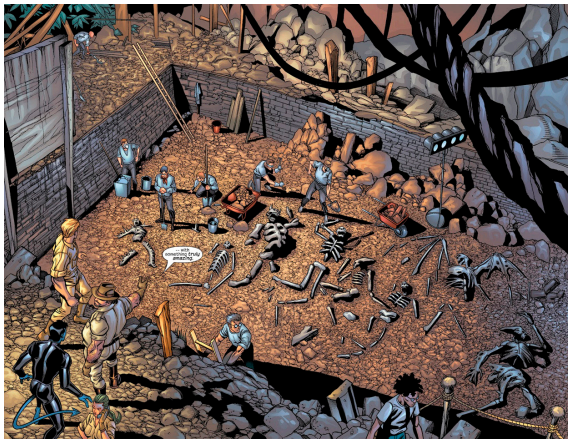

Figure 8. The finding of fossils of early mutants. From *Uncanny X-Men* #422 (UX#422: p. 3; Marvel Comics).

Extinction of mutants

Extinction is a frequent element around mutants in the Marvel Universe. The group has faced this possible destiny more than once, and due to different causes. In two points in their history, they were very close to extinction. The first one was during the story arc "Powerless!" (UX1#379-380, X2#99), due to the actions of the villain High Evolutionary (geneticist Herbert Wyndham). All mutants around the world were de-powered, perhaps by disabling the expression of the X-Gene. The second (and more dangerous) one was known as "M-Day" (HM#7), caused by Scarlet Witch's (the avenger Wanda Maximoff) magic spell. The words "No more mutants" cancelled the mutations of 90% of mutants and could have acted in a similar form to the cure of Kavita Rao mentioned above, but with a magical origin. The biological effects of this spell were indicated by the mutant scientist Beast in the story arc "Endangered Species" (X2#200) (Fig. 9). Also, no new mutants were born after that event, dooming the mutant species to extinction. Fortunately, the birth of Hope Summers occurred during Messiah Complex (XMC#1) and the extinction of mutants was prevented.

REFERENCES CITED

Two types of references are listed separately below: comic books and other literature (academic, encyclopedic, etc.). Comic book references are in accordance to the

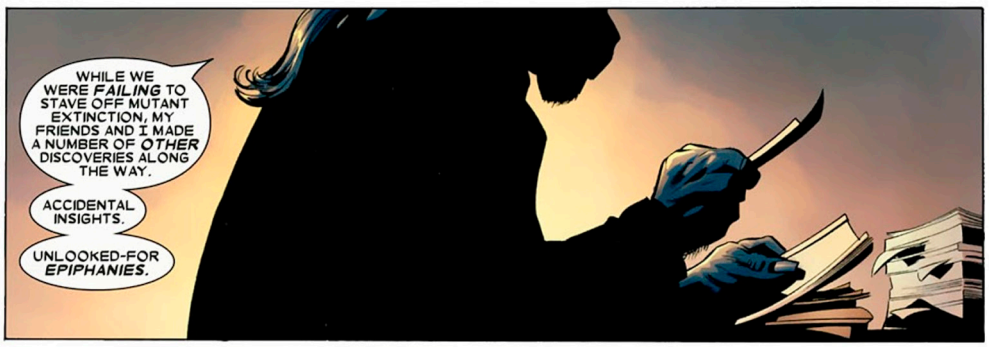

Figure 9. The mutant scientist Beast faces the extinction of mutants. From *X-Men Vol. 2* #200 (X2#200: p. 41; Marvel Comics).

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SYSTEMATIC APPENDIX

Genus *Homo* Linnaeus, 1758

Species *Homo sapiens* Linnaeus, 1758

Subspecies *Homo sapiens superior* Lensherr, 1963 (X1#1)

Diagnosis. Species of genus *Homo* with variable external appearance, with the presence of active X-Gene. This gene is expressed in different forms, some of them including superhuman powers.

Remarks. Despite the difficulties to differentiate species and subspecies of the genus *Homo* based on morphological features (Stringer & Buck, 2014), genetic particularities are enough to distinguish mutants as unique. Also, mutants often present

extraordinary characters that allow them to be recognised even in fossil or archaeological records (UX1#422) (Fig. 8) and their past record can be tracked. Mutants have a great amount of diversity among individuals and developed their own cultural signs and social behaviours, but they represent the great diversity present in real-world humans (Morrison, 2011). The choice of mutants as a human subspecies instead of as a separate species is due to the possible interbreeding between both groups, according to the well-established Biological Concept of Species (Mayr, 1942). A second reason is to follow "Xavier's dream", a statement frequently pointed out in mutant comic books about coexistence of humans and mutants as a single species.

Disclaimer

The present article uses real-world scientific knowledge to interpret a comic book universe; it is written in a playful manner, as if we were part of that latter universe. Neither the author nor the Journal of Geek Studies or its editors endorses eugenics, genetic modification of humans, or the division of Homo sapiens into subspecies.

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About the author

Dr. **Damián Pérez** is a big fan of comic books who spends a lot of time reading them. His favourite mutant characters are Wolverine and Nightcrawler. Also, he is a paleontologist studying the evolution and systematics of bivalves (among other things). He is currently a researcher in the Instituto Patagónico de Geología y Paleontología at Puerto Madryn, Chubut, Argentina.

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Pokécrustacea: the crustacean-inspired Pokémon

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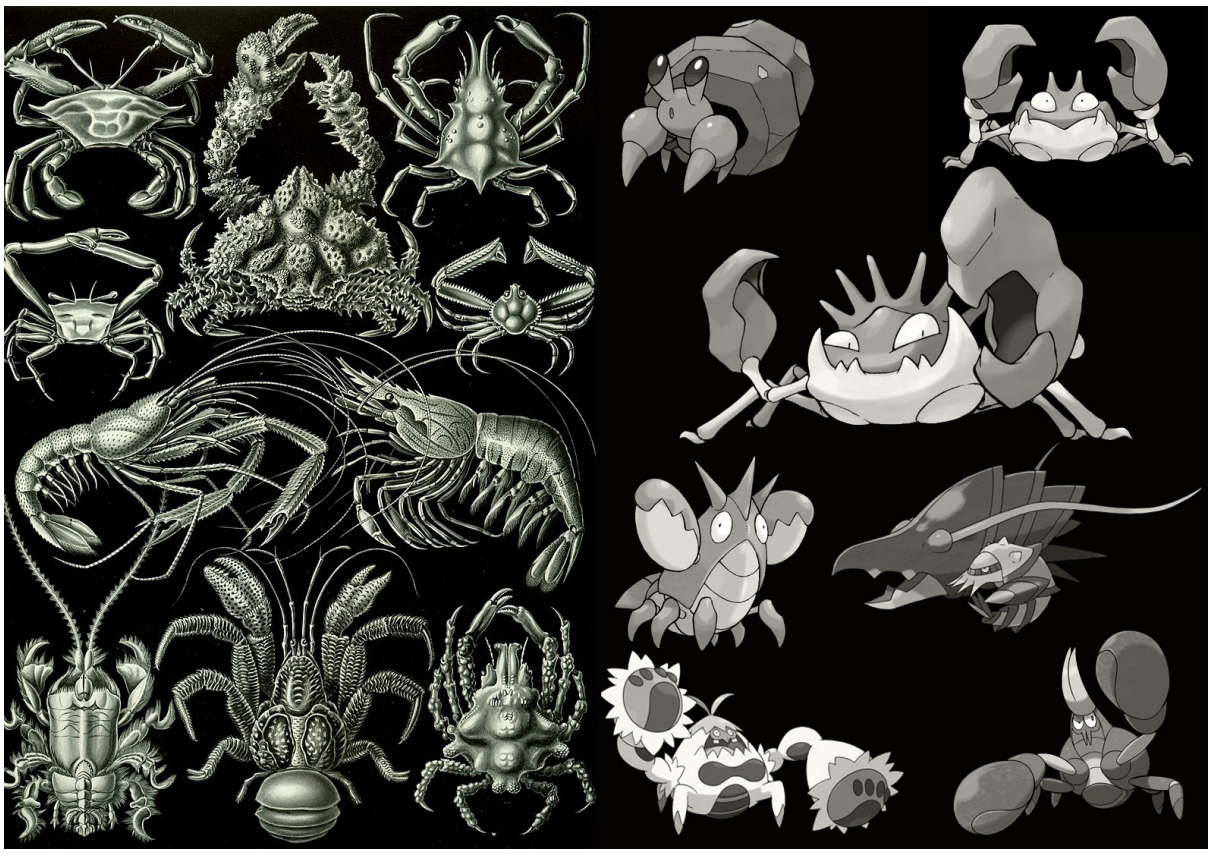
Crustaceans are a large and incredibly diverse group of very familiar animals such as crabs, lobsters, shrimps, woodlice, barnacles, and their allies. As full-fledged arthropods (invertebrate animals with an exoskeleton, a segmented body, and paired jointed appendages), they comprise over 70,000 species (Brusca et al., 2016) ranging in size from a fraction of a millimeter to respectable few meters of leg span (e.g., the Japanese spider crab can reach a whopping 3.8 m or 12.5 ft). They are quite an ancient group, ranging back to the Cambrian period some 511 million years ago. Some existing animals are virtually identical to fossilized forms from the Triassic, dating back 200 million years ago.



Left: Decapods, from German zoologist Ernst Haeckel's 1904 work "Kunstformen der Natur". Right: Pokémon inspired by real-world decapods.

Despite being classically identified as a group of their own, recent studies have shown that Crustacea is actually a paraphyletic taxon (that is, a group of animals that doesn't include all descendants of their common ancestor) and that some crustaceans are more closely related to Hexapoda (insects and their allies) than to other crustaceans (Regier et al., 2010; Lozano-Fernandez et al., 2019). Evolutionarily speaking, this means that insects are a strange group of air-breathing winged crustaceans (and that a Bug Type for a crustacean Pokémon is not biologically incorrect after all). Nonetheless, the traditional grouping of "classic" crustaceans, though now considered informal, is still used for practical purposes. Furthermore, the insect Pokémon have already been addressed by Kittel (2018).

Crustaceans are mostly aquatic or semi-aquatic, of course, with exceptions such as the terrestrial woodlice that are commonly found in gardens. Humans are known to feed on crustaceans quite intensely, which is one of the reasons why these animals are featured in several aspects of our culture from tapestry, paintings, sculptures, folklore and mythology (constellations even!) since time immemorial. More recently, though, crustaceans have been depicted quite often in movies and even electronic media, especially games. Much like the equally amazing mollusks (see Cavallari, 2015; Salvador & Cavallari, 2019), several games include crustaceans showing up as funny cameos, fierce adversaries (e.g., Final Fantasy series), and more rarely as some of the main stars.

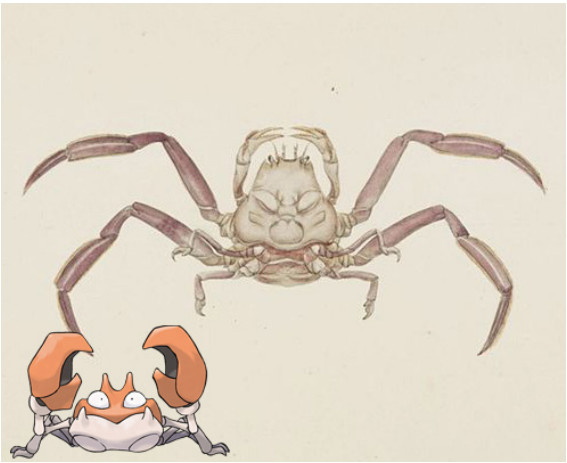
In the Pokémon franchise, crustaceans play an important role, having inspired some of the coolest monsters out there. The goal of this article is to present the crustacean-based Pokémon, discuss their real-world inspiration and explain a little bit about their biology. We outline specific features of the real animals that were transported to the games (such as types, moves, abilities, etc.) whenever possible.

"Crayfish and Two Shrimps", by Utagawa Hiroshige, 1835–1845.

LIST OF CRUSTACEAN POKEMON

Krabby

(#98; Type: Water)



Krabby (bottom left) and a drawing/watercolor illustration of the samurai crab, *Heikeopsis japonica* (von Siebold, 1824) from the Naturalis Biodiversity Center Art Collection (catalog number RMNH.ART.79).

Class: Malacostraca

Order: Decapoda

Infraorder: Brachyura

Family: Dorippidae or Dotillidae

Genus: *Heikeopsis* Ng, Guinot & Davie, 2008, *Dotilla* Stimpson, 1858, or *Scopimera* De Haan, 1833

Species: *Heikeopsis japonica* (von Siebold, 1824), *Dotilla* sp., or *Scopimera* sp.

Together with Kingler, Krabby is perhaps one of the most iconic crustacean Pokémon. Not only because of its resemblance to real-world crabs, which are arguably the most well-known crustaceans, but also because it was the only crustacean Pokémon for a long time in the franchise. This situation was changed only after the introduction of Corphish in Gen. III (#341, see below). Yes, to our chagrin, the *Pokémon* franchise had an entire generation without crustaceans.

Biologists classify crabs in the order Decapoda (from the Ancient Greek δἑκα, *déca*, 'ten' + ποὑς, *poús*, 'foot'), a major group that includes many familiar animals besides crabs, such as crayfish, crabs, lobsters, prawns, and shrimp. Decapods can have dozens of appendages arranged in one pair per body segment, ten of which, as the name implies, are considered legs. Within the Decapoda, the infraorder Brachyura (a New Latin name derived from the Ancient Greek: βραχύς, *brakhús*, 'short' + οὐρά, *ourá*, 'tail') contains the taxa (groups of organisms) known as the "true crabs". True crabs have a symmetrical but much reduced abdomen (technically known as pleon) that is usually flexed beneath the thorax (a.k.a. pereon), a dorso-ventrally flattened body protected by an expanded carapace (Brusca et al., 2016). They usually have characteristic well-developed claws. Most of these traits are present in Krabby's design (and Kingler's as well, see below) and leave no doubt about its "true crab" inspiration. However, Krabby's generic and stylized appearance makes it difficult to work out a real-world classification beyond that level.

Bulbapedia (2020) speculates that Krabby's design may be based on the samurai crab, *Heikeopsis japonica* (von Siebold, 1824). In our opinion, reaching this conclusion only from the generic design might be a stretch, but there are some interesting elements to consider. Most crabs we know have well-developed clawed appendages and four pairs of similarly-sized walking appendages or legs (a.k.a. pereiopods). Krabby only has two pairs of walking legs, which is quite unusual for crabs in general. But, interestingly, although samurai crabs have four pairs of legs, two of them are much reduced. This could have misled designers, or these two pairs of legs could have been omitted to avoid a messy design. Moreover, *H. japonica* specimens are often red and white much like Krabby, which is further evidence in favor of this hypothesis.

A sand bubbler crab (*Scopimera globosa*) and its sand bubbles. Photo by Dcubillas (CC-BY-3.0).

Still according to Bulbapedia, other real-world inspiration candidates for Krabby's design are the sand bubbler crabs. Those crabs belong to the genera *Dotilla* or *Scopimera*, and are named after the habit of feeding by filtering organic material (e.g., detritus and stranded plankton) present in the sand, leaving behind small balls made of the substrate. They are very common in the Indo-Pacific (including Japan), usually found on tropical and sub-tropical sheltered sandy beaches (Maitland, 1986). Indeed, a Pokédex statement seems to point in that direction: "If it is unable to find food, it will absorb nutrients by swallowing a mouthful of sand" (Gen. II, *Pokémon Crystal*). In any case, the matter is still inconclusive.

One last note: the way this Pokémon's eyes are drawn does not match the eyes of the crabs that probably inspired its design. Both samurai crabs and sand bubbler crabs have pedunculated eyes: that is, the eyes are on the distal end (tip) of eye-bearing appendages. In fact, Krabby's little "double horns" could actually be said appendages. The same partially applies to its evolved form, Kingler (the double horns are absent).

Kingler

(#99; Type: Water)

The red king crab, *Paralithodes camtschaticus* (photo by The Children's Museum of Indianapolis), and Kingler (bottom right).

Class: Malacostraca

Order: Decapoda

Infraorder: Brachyura and Anomura

In the *Pokémon* franchise, the design usually tends to highlight more aggressive features to provide evolved forms with a fiercer appearance. This is certainly true for Kingler, which evolves from the milder-looking Krabby. As in the previous stage, Kingler's identity as a decapod crustacean is quite clear. However, it is from there that things start to get messy.

Kingler's claws are disproportionate, one being much larger and more prominent than the other. This feature is seen in the real world animals known as fiddler crabs. In fact, Kingler's name seems to be an amalgam of the words "king" and "fiddler", according to Bulbapedia (2020). Nevertheless, much like Kingler, the oversized claw of fiddler crabs, which belong to the infraorder Brachyura (the true crabs, see Krabby above), is one of their most remarkable features. The Pokédex states that "Kingler has an enormous, oversized claw. It waves this huge claw in the air to communicate with others" (Gen. III, *Pokémon Ruby*). Real world fiddler crabs do communicate using a sequence of waves and gestures with their claws. In males, the larger claw is also used in courtship and copulatory disputes (Pope, 2000; How et al., 2008).

This brings us back to the matter of the aggressive appearance of the evolved forms: besides the malicious grin, Kingler presents a set of spikes that resemble a crown, hence its name. Well, actually, there is a group of particularly spiny crustaceans known as king crabs, a.k.a., the superfamily Lithodoidea. Unlike the brachyurans (see Krabby above), lithodoideans are not true crabs: they belong to the infraorder Anomura, the sister taxon (the closest relative) of Brachyura. Interestingly, those animals do have a body asymmetry, for example between their claws, which is supposedly due to a common ancestry with hermit crabs (Noever & Glenner, 2018). Therefore, it is highly likely that inspiration for Kingler's design was drawn from both fiddler crabs and king crabs.

Several iterations of the Pokédex highlight the "overwhelming power" of kingler's claws, offering 10,000 hp (horse power) as an exciting measurement of strength. This type of unit is generally not used to measure the gripping pressure of animal claws or bites; instead, the measurement is usually given in Newtons. Some of Kingler's attacks allude to his giant claw and its respective powerful grip: Hammer Arm, Metal Claw, Crabhammer, Guillotine, and X-Scissor. Nevertheless, the real-world crab with the most impressive gripping strength is the coconut crab (*Birgus latro*), which we will discuss below in Crabrawler's entry. We believe that this repeated allusion to the strength of Kingler's claws has more to do with its design, which exacerbates the difference in size between the claws, than something based on the biology of real-world crustaceans.

One last interesting detail: Kingler has a Gigantamax form, a new category introduced in Gen. VIII. The design seems to be loosely based on the Japanese spider crab, the largest living crustacean. Either way, the design tends to exaggerate shapes and

proportions, which prevents us from analyzing it further.

Corphish

(#341; Type: Water)

Procambarus clarkii taken near a lake in Gironde, France, photo by Duloup (CC BY 3.0) and Corphish (bottom right corner).

Class: Malacostraca

Order: Decapoda

Superfamily: Astacoidea

Family: Cambaridae

Genus: *Procambarus* Ortmann, 1905

Species: *Procambarus clarkii* (Girard, 1852)

Corphish, with its clawed appendages and flat tail, is clearly reminiscent of crayfishes and lobsters. These two crustaceans are closely related and share many similarities, such as bearing claws on the first pair of appendages, a tough carapace covering the head and thorax, and a tail fan at the end of the abdomen. Nonetheless, their ecologies differ considerably: lobsters are restricted to saltwater environments, as opposed to the exclusively freshwater crayfishes. Furthermore, one can tell them apart from their general body proportions, as lobsters tend to be bigger and much longer than crayfishes. Corphish is usually found in lakes, which seems to indicate it is a crayfish. Additionally, Bulbapedia (2020) suggests that the name Corphish might be derived from the word "crayfish" itself. Although Corphish's design is quite generic and lacks the characteristics needed to identify its species, there is some interesting information that can help us pinpoint this Pokémon's real-world inspiration.

According to Pokédex, Corphishes were "originally foreign Pokémon that were imported as pets", and "individuals that have been set free by Trainers who could no longer raise them have become common, and they can now be found in Alola". In other words, Corphish is an exotic species introduced to Alola, which is the equivalent of Hawaii in the *Pokémon* world. While some introduced species can have neutral or even positive impacts, most are often a problem to local ecosystems. The worst offenders are the so-called invasive species. They spread fast, have few or no natural predators at the invaded areas and quickly outcompete the local species, causing varying degrees of damage to the environment. Most readers will probably be familiar with some invasive species (in fact, one could argue that humans themselves are one of the world's most successful invasive species out there). Some examples include the house sparrow (*Passer domesticus*), the giant African land snail (*Achatina fulica*) and the congograss (*Imperata cylindrica*), all very widespread outside their original range. If you live on an island, this problem might be even more evident. Insular ecosystems tend to host a myriad of unique species that evolved in isolation from the continent for millions of years and are not prepared to compete with their alien cousins. Corphish shows signs of being a potential invasive species. Present and past iterations of the Pokédex state that "no matter how dirty the water in the river, it will adapt and thrive" (Gen. VIII, *Pokémon Sword*) and that "this Pokémon is very hardy and has greatly increased its population" (Gen. III, *Pokémon Ruby*). Its biological resilience indicates that Corphish can — and likely will — outcompete any endemic crayfish Pokémon in invaded areas.

Curiously, there is a famous case of an invasive crayfish with the same profile: *Procambarus clarkii*, the red swamp crayfish. *Procambarus clarkii* is native to southern USA and northern Mexico, but has been widely introduced to many continents and islands, including Hawaii. Able to breed fast and tolerate environmental conditions that would be hostile to most crayfishes (e.g. low levels of dissolved oxygen or moderate salinity), *P. clarkii* is considered one of the most resilient crustaceans. Following its introductions, *P. clarkii* has changed entire ecosystems, removing water plants through grazing (and thus allowing the proliferation of phytoplankton), preying on native invertebrates, fishes and tadpoles, and even carrying diseases that are lethal to other species of crayfish (Loureiro et al., 2015).

Therefore, it seems that Corphish is the *Procambarus clarkii* of the Pokémon world and, as such, we can only hope it is less noxious to Alola's ecosystem than its real-world counterpart is to invaded areas.

Crawdaunt

(#342; Type: Water)

Crawdaunt.

Class: Malacostraca

Order: Decapoda

Superfamily: Astacoidea

Crawdaunt is yet another example of the trend to provide evolved forms with aggressive features and a more ferocious overall appearance: the spikes on the claws and legs are an undeniable testament to this intention. In the specific case of Crawdaunt, the temperament is also more aggressive, as the Pokédex reiterates for several generations, mentioning its "extremely violent nature" (Gen. III, *Pokémon Ruby*), or flat out stating that it is "a brutish Pokémon that loves to battle" (Gen. III, *Pokémon Emerald*) and even "a ruffian that uses its pincers to pick up and toss out other Pokémon from its pond" (Gens. IV to VI, several games). Those statements may be a nod to the competitive behavior of *P. clarkii* as an invasive species (see Corphish, above). Anyway, as unfortunately sometimes happens, the more stylized design of the evolved form prevents further conclusions on the biological classification of this Pokémon, though one could assume it is also inspired on *P. clarkii* based on its behavior.

Interestingly enough, the Pokédex highlights the fact that Crawdaunt "molts [sheds] its shell regularly. Immediately after molting, its shell is soft and tender. Until the shell hardens, this Pokémon hides in its streambed burrow to avoid attack from its foes" (Gen. III, *Pokémon Sapphire*, and Gen. VI, *Pokémon Alpha Sapphire*). This exoskeleton-shedding process is very real, and is known technically as ecdysis. It actually occurs in a huge group of animals known as Ecdysozoa, which includes arthropods and other groups (Telford et al., 2008).

Dwebble

(#557; Type: Bug / Rock)

Dwebble (top left), and the hermit crab *Cancellus typus* (photo by Michael Marmach, Victoria Museum (CC BY 4.0).

Class: Malacostraca

Order: Decapoda

Family: Diogenidae

Genus: *Cancellus* H. Milne Edwards, 1836

It takes no biology major to notice that Dwebble's design was based on hermit crabs. These charismatic crustaceans are known and loved by many, with some species being commonly kept as pets. There are approximately 1,110 known species of hermit crabs, all belonging to the clade Paguroidea. Most hermit crabs are marine, but there is at least one species known to live entirely in freshwater (*Clibanarius fonticola*) and 17 land-dwelling species. The terrestrial hermit crabs belong to the family Coenobitidae, which includes the titanic *Birgus latro*, or coconut crab, the largest terrestrial invertebrate of all (see Crabrawler below).

More than anything else, hermit crabs are known for their peculiar use of molluscan shells. Unlike other crustaceans, these crabs have soft abdomens that lack the tough exoskeleton found on the rest of the body. Of course, such a vulnerability would not go unnoticed by the ruthless workings of natural selection — and this is where the shells come in. These ingenious crabs scavenge shells left by dead mollusks and wear them as a mobile shelter or body armor to protect their soft parts. While they seem to prefer shells that are already empty, a desperate crab might even kill a mollusk to steal its shell in times of shortage. The most common targets seem to be snail shells, but there are species known to wear shells of bivalves and scaphopods, while others might even use corals or hard tubes secreted by annelids. In fact, hermit crabs are so well adapted to wear snail shells that most of them even have a coiled and asymmetrical abdomen, which is perfectly fit for holding on to the shell's columella or axis.

So that brings us back to Dwebble. While it is clearly a hermit crab, a careful eye might have noticed that this Pokémon does not wear a shell, but a rock. Dwebble's seemingly unique behavior has been discussed in Salvador & Cavallari (2019), where it is tentatively associated with hermit crabs known to wear fossilized shells or corals instead of regular shells. Nonetheless, we propose a different take on Dwebble's biology: the answer might be on a rather obscure, yet very interesting, genus of hermit crabs.

Ladies and gentlemen, we present you *Cancellus*. With 16 recognized species, *Cancellus* is distinctive among hermit crabs for a series of reasons, such as having a mostly symmetrical and uncoiled abdomen. Most interesting, however, is the fact that *Cancellus* crabs are known not to wear molluscan shells. Some species substitute the shells for siliceous sponges, calcareous algae, dead corals or annelid tubes, but most seem to prefer sedimentary or volcanic rocks (McLaughlin, 2008). Much like our little friend Dwebble, *Cancellus* carries its rocky shelter for protection and can fit its entire body inside a cylindrical cavity on it. Pokédex states that Dwebble makes its own hole, with aid of a liquid secreted from its mouth, but we currently don't know how *Cancellus* digs the cavity on its rock, or whether it is dug by them at all (Mayo, 1973).

There is one problem with this analogy though: Dwebble is terrestrial. All known species of *Cancellus* are marine, much like your regular hermit crab. In fact, they are

not even closely related to the terrestrial Coenobitidae. Then how can Dwebble be both terrestrial, like coenobitids, and carry a rock, like *Cancellus*?

One could argue that Dwebble is actually a coenobitid that started to use rocks independently from *Cancellus*, being a curious case of convergent evolution. This hypothesis is not supported by morphology though, seeing that Dwebble's body is symmetrical and uncoiled, much like *Cancellus* and unlike any species of Coenobitidae. Thus, we suggest an alternative hypothesis: Dwebble is, actually, a species of *Cancellus* that independently acquired a terrestrial lifestyle. An independent transition from water to land would not be unheard of, considering that arthropods (which includes crustaceans) are notorious for having invaded land at least seven times in separate lineages during their evolution (Dunlop et al., 2013).

So, could Dwebble be inspired by a little-known genus of stone-bearing hermit crabs? More than that, could it be considered a new species within that genus (*Cancellus dwebblei*, anyone?), independently forsaking its water-bound past in order to become the terrestrial crab we all know and love? Unlikely, but an amusing thought regardless.

Crustle

(#558; Type: Bug, Rock)

Crustle.

Class: Malacostraca

Order: Decapoda

Family: Diogenidae

Genus: *Cancellus* H. Milne Edwards, 1836

Crustle is very similar to Dwebble. It only seems to be the tough grown-up version (as usual) of our cute little hermit crab. In any case, most of the observations about Dwebble also apply to Crustle.

Binacle

(#688; Type: Rock / Water)

The Japanese goose barnacle, *Capitulum mitella* (photo by Daiju Azuma, CC BY SA 2.5), and Binacle (top right corner).

Class: Hexanauplia

Infraclass: Cirripedia

Superorder: Thoracica

Order: Scalpelliformes

Family: Pollicipedidae

Genus: *Capitulum* Gray, 1825

Species: *Capitulum mitella* (Linnaeus, 1758)

Most people might figure out that Binacle resembles a pair of goose barnacles, but what most people might forget is that barnacles are crustaceans. However, they are only distantly related to crabs and lobsters. While most of the well-known crustaceans are part of the clade Malacostraca, barnacles and their closest relatives belong to another clade, named Hexanauplia, along with the microscopic copepods (e.g., *SpongeBob's* Plankton).

The history of barnacle zoology, aptly named Cirripedology, is quite interesting in itself. These strange animals were once regarded as mollusks by classic taxonomists, such as Linnaeus and Cuvier, before being properly recognized as crustaceans. Later on, barnacle taxonomy was subject to the studies of the great Charles Darwin himself. Darwin's contributions to cirripedology are still regarded as of great importance, though Charles didn't seem to be so fond of them by the end of his work. In his own words, he stated: "I am at work on the second vol. of the Cirripedia, of which creatures I am wonderfully tired: I hate a Barnacle as no man ever did before, not even a Sailor in a slow-sailing ship" (Darwin Correspondence Project, 2020).

Goose barnacles, like Binacle, are distinguished by being adhered onto rocks and other hard substrates (e.g., a ship's hull, whales, sea turtles) through a flexible stalk or peduncle. Once adhered, the barnacle's body lies upside down, with the "tentacles" (or "fingers", in Binacle's case) actually being its legs. As if that wasn't weird enough, the soft parts of these odd crustaceans are completely encased within a hardened structure made of calcareous plates, which roughly correspond to other crustaceans' carapaces. Oh yeah, and they are also heartless (Brusca et al., 2016).

According to the Pokédex, two Binacle share a rock and cooperate for survival. In other words, this Pokémon lives in colonies, like real barnacles. These assemblages are a common sight in rocky shores, where large groups of barnacles live closely together in the intertidal rocks. Since the intertidal zone is limited and everyone wants their place in the sun, competition for space often becomes a problem. The most common contenders include other barnacles and mollusks such as mussels and limpets. As a result, it is not uncommon to find a great biodiversity of sessile invertebrates crowded together and constantly attempting to displace each other in these environments.

Binacle's Japanese name, *Kametete* (カメテテ), suggests that it was likely inspired by the species *Capitulum mitella*, a.k.a. the Japanese goose barnacle or *kamenote* (カメノテ) (Bulbapedia, 2020). In fact, Binacle's design shows a vague resemblance to *C. mitella*, but it is far too generic (and anatomically incorrect) to fuel a more in-depth discussion.

Barbaracle

(#689; Type: Rock, Water)

Barbaracle.

Class: Hexanauplia

Infraclass: Cirripedia

Superorder: Thoracica

Order: Scalpelliformes

Family: Pollicipedidae

Genus: *Capitulum* Gray, 1825

Species: *Capitulum mitella* (Linnaeus, 1758)

Not Barnacle Boy (from the show SpongeBob), but Barbaracle looks like an anthropomorphic barnacle. Again, this is a colonial Pokémon, formed once two Binacle multiply into seven through evolution. Unlike Binacle, however, the barnacles on Barbaracle seem to be fused and act as a single organism (despite having "minds of their own", according to the Pokédex). This is not unheard of in zoology, since colonial organisms like this are common in many taxa, such as bryozoans and corals. In such cases, individuals within a colony, known as zooids, are anatomically attached to each other. Some zooids can have specific functions within a colony (e.g., feeding zooids, defense zooids, reproductive zooids), which seems to be the case with Barbaracle's arm and leg "zooids".

Nonetheless, while real barnacles do live in colonies, they are not colonial organisms in this sense. Each barnacle in an assemblage is still very much an independent organism and not linked to its conspecifics in any way. Essentially, it's every barnacle for itself out there. It's unclear whether Barbaracle is a full-fledged colonial organism or just a particularly cooperative assemblage of barnacles, but it seems to lean towards the former. Anyway, aside from this oddity, Barbaracle is very similar to Binacle in most aspects. It was probably inspired by *Capitulum mitella* as well, since its Japanese name (*Gamenodes*, ガメノデス) also stems from the word *kamenote*.

Clauncher

(#692; Type: Water)

Clauncher (top left) and the pistol shrimp *Alpheus eulimene* (photo by Moorea Biocode, CC BY NC 3.0).

Class: Malacostraca

Order: Decapoda

Infraorder: Caridea

Superfamily: Alpheoidea

Family: Alpheidae

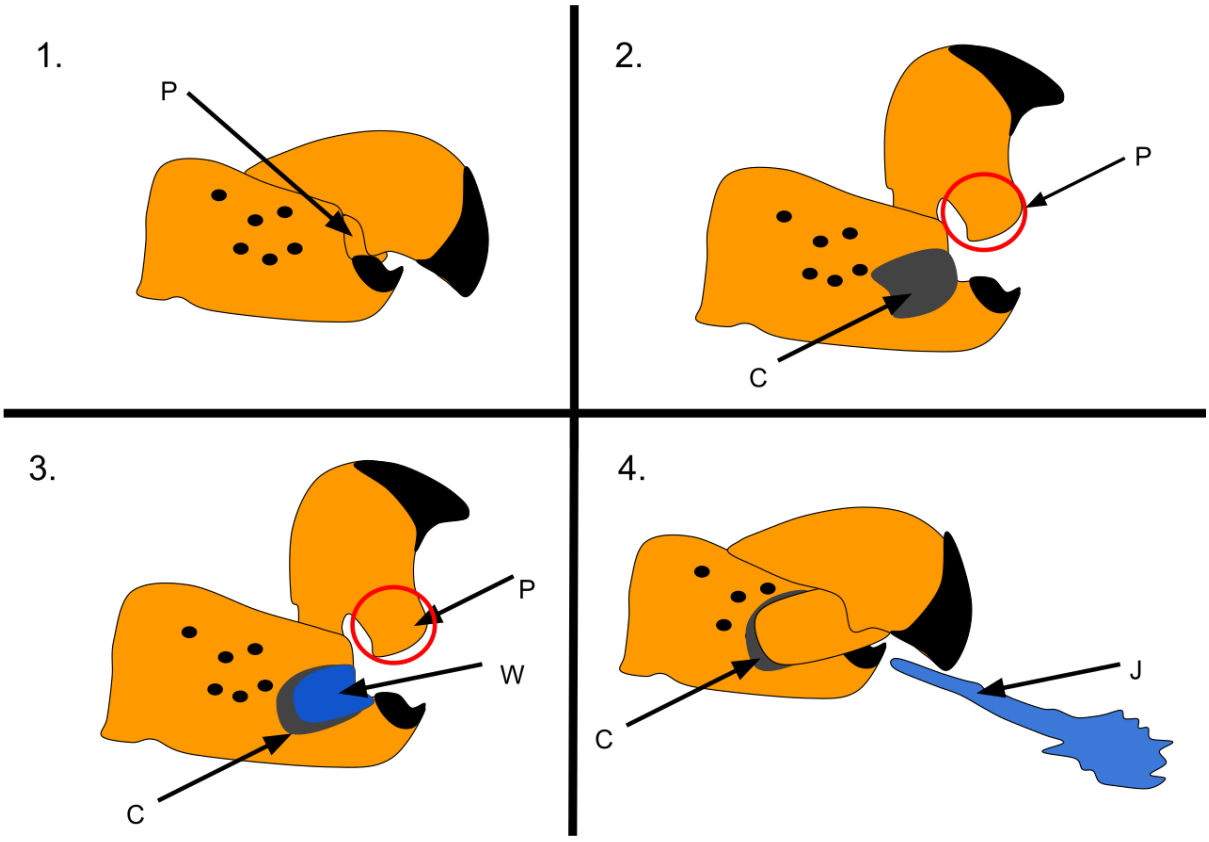
Genus: *Alpheus* Fabricius, 1798

Species: *Alpheus eulimene* De Man, 1909

Clauncher's design is probably based on *Alpheus eulimene*, a blue-and-yellow shrimp species with black stripes that is widely distributed in the Pacific, including Japan (Sha et al., 2019). It belongs to the very pe-

culiar family Alpheidae, a.k.a. the snapping shrimps or pistol shrimps. Pistol shrimps are known for their characteristic asymmetrical claws, the larger of which can be used to produce an incredibly loud snap. In fact, a pistol shrimp's snapping sound can reach up to 210 decibels (Versluis et al., 2000), which is even louder than an actual gunshot (around 150 decibels). Despite being just a few inches long (3–5 cm or 1.2–2.0 in), pistol shrimps are so noisy they compete with gigantic sperm whales and belugas for the title of the loudest animals in the ocean!

And it's not all about noise: by snapping its claw shut, a pistol shrimp produces a highly pressurized and very fast jet stream. The water is forced to move so fast it evaporates producing a small vapor-filled cavity known as a cavitation bubble, which travels at breakneck speed along a short distance (ca. 4 cm). By using the trail the bubble leaves behind, the average speed of the water jet can also be estimated at 90 km/h (Versluis et al., 2000). If that weren't enough, when the cavitation bubble collapses, it releases a massive amount of energy and produces a huge amount of heat, reaching temperatures of over 5,000 K or 4,700 °C (Lohse et al., 2001), which is close enough to the temperature of the sun's surface (circa 5,800 K or 5,500 °C)! Of course, all this heat is generated on a very small scale, but that doesn't make this virtual underwater hadouken any less awesome (or proportionally powerful). Oh, and did we mention that this phenomenon also produces light? Light generated this way is actually a very exclusive kind of bioluminescence, a.k.a. the production and emission of light by a living organism, that only pistol shrimps can pull off (see Lohse et al., 2001).



A real-world pistol shrimp's snap at work. 1. Closed pistol shrimp claw with slightly hidden plunger (P). 2. Open claw with exposed plunger (P) and socket (C). 3. Open claw with water (W) entering the socket (C). 4. Closed claw with plunger (P) pushed into the socket (C), forcing a jet stream (J) out. Diagram by Carvermyers (CC BY SA 4.0).

Still regarding the snap itself, one might wonder what it is used for. Real-world pistol shrimps use it to communicate among themselves through sound. However, it can also be used as a weapon, since the resulting shockwave is powerful enough to stun or even kill small prey (Versluis et al., 2000). So Clauncher's Water Gun and Bubble attacks both probably allude to that unusual and powerful hunting strategy. The Pokédex even supports this idea by stating that "they knock down flying prey by firing compressed water from their massive claws like shooting a pistol" (Gen. VI, *Pokémon X*), and even more directly states that "by detonating gas that accumulates in its right claw, this Pokémon launches water like a bullet. This is how Clauncher defeats its enemies" (Gen VIII, *Pokémon Shield*).

On its account on Clauncher in *Pokémon Ultra Sun* (Gen. VII), the Pokédex states that "[its] claws occasionally fall off, and it keeps a low profile until they grow back". Well, this is actually kind of true for real-world pistol shrimps. They can regenerate claws that have been torn off, but instead of "keeping a low profile" while it grows back, they actually transform the remaining regular claw into a snapping one. This in turn inhibits the newly regenerating claw from transforming into a snapping claw too. Thus, eventually, a pistol shrimp's pistol can switch sides, which makes them harder to disarm (Read & Govind, 1997).

Clawitzer

(#693; Type: Water)

Clawitzer.

Class: Malacostraca

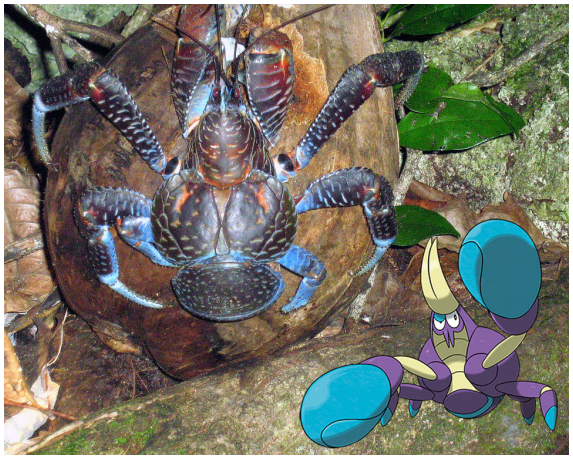
Order: Decapoda

Family: Alpheidae

Clawitzer's design maintains the pistol shrimp-themed appearance like Clauncher, though it is much more stylized. As usual in the evolved forms (see comments in Kingler's entry above), it has exaggerated traits and a more aggressive semblance. Its name is an amalgam of two words, "claw" (an obvious reference) and "Howitzer", a type of cannon-like artillery piece, alluding to Clawitzer's cannon-like right claw. To complete the more ferocious appearance, the main claw appears to have been designed to look like the head of a large beast, possibly a wolf or even more likely, a dragon, as Clawitzer has a dragon-themed attack (Dragon Pulse). In any case, most of the observations about Clauncher also apply to Clawitzer, but due to the stylized design, any classification beyond family level would be a stretch.

Crabrawler

(#739; Type: Fighting)



The coconut crab, *Birgus latro* (photo by fearlessRich, CC BY 2.0), and Crabrawler (bottom right).

Class: Malacostraca

Order: Decapoda

Family: Coenobitidae

Genus: *Birgus* Leach, 1816

Species: *Birgus latro* (Linnaeus, 1767)

With powerful pincers and a tendency to pick fights, Crabrawler is the boxer of Pokécrustaceans. This heavyweight fighter is inspired by an equally powerful and heavy crustacean: *Birgus latro*, a.k.a. the coconut crab, robber crab or palm thief. As we've mentioned before, the coconut crab is the largest terrestrial invertebrate in modern times. The largest individuals can weigh up to 4 kg and measure 1 m in width (including the legs), which is a gargantuan size when compared to the heaviest recorded insect (a giant weta) at 71 g. As a side note, the title of largest land arthropod of all time still goes to the giant *Arthropleura* millipedes of the Late Carboniferous, which could grow up to 2.5 m long and probably weigh several kilograms.

Interestingly, *Birgus latro* is a hermit crab and the young ones are even known to carry gastropod shells. By contrast, the adults are too big to fit inside any available shell and compensate for this vulnerability by hardening the exoskeleton in their abdomens during growth. Like all hermit crabs, *B. latro* belongs to the clade Paguroidea, which means that Crabrawler is closely related to Dwebble and Crustle (and possibly Kingler, if it is indeed a king crab). Unlike those Pokémon, however, coconut crabs are part of the family Coenobitidae, along with the other land-dwelling hermit crabs (except Dwebble and Crustle, as discussed in the former's entry).

As mentioned earlier in Kingler's entry, the coconut crab has the strongest grip of all crustaceans. Their pinching force has been recorded to reach striking 1,765 N (newtons), but some estimates suggest that larger individuals might even reach up to 3,300 N. Not only is this stronger than the pinching force of all other crustaceans, but it's also stronger than the bite forces of most terrestrial predators. On top of that, coconut crabs are also capable of lifting weights many times heavier than themselves, with some individuals reported to lift up to 28 kg (Oka et al., 2016). With that in mind, it comes as no surprise that Crabrawler's moves include Hyper Cutter and Iron Fist.

Despite its weight, the coconut crab is also an excellent climber. Their legs are particularly long and muscular, capable of bearing the crab's weight in nearly vertical climbs. Those crabs are often observed climbing coconut trees in their natural habitat, which seems to be mostly a way to escape predators. Interestingly, the Pokédex states that "Crabrawler has been known to mistake Exeggutor for a coconut tree and climb it", though we doubt that this fierce Pokémon would try to flee from an adversary rather than fight it.

What kind of predator could eat these crabs though? Other coconut crabs, of course! These animals are omnivorous and their diet consists mostly of fruits, seeds and occasionally carrion, but coconut crabs are known to prey upon other crabs (including their own kin), rats and even large birds (Wilde et al., 2004; Kessler, 2005; Laidre, 2017). Coconut crabs are also consumed by humans, but their flesh might be toxic de-

pending on the crab's diet (Mailaud et al., 2010). This does not seem to be the case for Crabrawler though, as the Pokédex states that the meat on their pincers, while scarce, is "rich and delicious."

Crabominable

(#740; Type: Fighting / Ice)

The yeti crab, *Kiwa hirsuta* (photo by Andrew Thurber, CC BY SA 2.0), and Crabominable (bottom right corner).

Class: Malacostraca

Order: Decapoda

Family: Kiwaidae

Genus: *Kiwa* Macpherson, Jones & Segonzac, 2006

Species: *Kiwa hirsuta* Macpherson, Jones & Segonzac, 2006

Crabrawler's evolved form is noteworthy because, unlike the ones discussed earlier, it looks like a completely different animal. In fact, it looks like two completely different animals, since Crabominable's design shows a strange mix of mammalian and crustacean features. It is clearly a crab, with paired articulated appendages, a compact body and an abdomen folded beneath its body. However, it also has white fur, paw-like pincers, a mouth with teeth and a tongue, and a thorax very reminiscent of gorillas. As its name suggests, Crabominable's mammalian aspects are inspired by the legendary Yeti, or Abominable Snowman, a folkloric ape said to inhabit the tall mountains of the Himalayas. Most descriptions of the Yeti make no mentions of crustaceans though, with the notable exception of the Cthulhu Mythos' Mi-Go (crustacean-like eldritch horrors that are said to be the in-universe inspiration for the Yeti legends).

There is, however, one species of crustacean that has been dubbed the "Yeti crab": *Kiwa hirsuta*. It is unique in having appendages densely covered by long, hair-like setae, granting those crabs a rather furry appearance. *Kiwa hirsuta* is a deep sea species, inhabiting hydrothermal vents in the South Pacific Ocean, where it likely feeds on bacteria and meat. Nonetheless, despite being likely inspired by this crab, the similarities between Crabominable and its real-world counterpart are little more than the white fur-like integument and the association with the Yeti. Unlike *K. hirsuta*, Crabominable is fully terrestrial, lives at the alpine tundra of high mountains and has a much more compact body (not to mention its clearly gorilla-inspired features).

Interestingly, the Pokédex mentions that this Pokémon "got lost and ended up on a snowy mountain", where it "evolved and grew fur" in response to the cold environment. This could indicate that Crabominable belongs to a new species altogether, perhaps not even related to the *Kiwa* genus at all. How would a lost crab evolve into an ape-crab hybrid with ice powers remains a mystery, but, then again, evolution in the Pokémon franchise does not work like biological evolution at all.

Wimpod

(#767; Type: Bug, Water)

A sea slater (*Ligia* sp.; photo by me'nthedogs, CC BY 2.0) and Wimpod (upper right corner).

Class: Malacostraca

Order: Isopoda

Unlike the other Pokémon discussed so far, Wimpod is not based on crabs or shrimps, nor is it a barnacle. The design of this Pokémon is based on a relatively less familiar type of crustacean belonging to the Order Isopoda. It includes the sea slaters, pillbugs, roly-polies, and their allies. The name Isopoda is New Latin, derived from Ancient Greek ἴσος (*ísos*, 'equal') and πούς (*poús*, 'foot'), alluding to its numerous similarly-sized paired legs. They are a huge 300-million-years-old group including over 10,000 species distributed worldwide in marine, freshwater and terrestrial environments.

Golisopod

(#768; Type: Bug / Water)

The giant isopod, *Bathynomus* (photo by Emily Osterloff, Natural History Museum, London), inspired the design of Golisopod (top left).

Class: Malacostraca

Order: Isopoda

Suborder: Flabellifera

Family: Cirolanidae

Genus: *Bathynomus* A. Milne-Edwards, 1879

Judging by its name (an amalgam of 'goliath' + 'isopod'), the numerous paired appendages and articulated heavy armor (or exoskeleton), Golisopod's design is most likely based on a group of impressive deep-sea dwellers: species in the genus *Bathynomus*, commonly known as the giant isopods. Distant relatives of shrimps and crabs, giant isopods are closely related to woodlice, which are quite small (a few millimeters to 5 cm), but are many times as large. Some species (*Bathynomus giganteus*, for instance) attain a typical length of about 30 cm, with the largest recorded specimen reaching a whopping 50 cm or nearly 20 inches (McClain et al., 2015).

DISCUSSION

As stated by Aristotle, art imitates life, and Pokémon designs make it clear. We can see that these creatures are inspired by real animals or combinations of different animals. Some of them look tougher than real life crustaceans, or show fewer legs, which is understandable when you consider all those legs would need to be animated. The similarities are not only related to their looks, but also to their attacks, distribution and habitats they occupy: Clauncher and Clawitzer, for instance, borrow their attack patterns and cool in-game facts from the extraordinary biology of pistol shrimps. Even real-world biological problems are addressed indirectly, e.g., Corphish and Crawdaunt, which reflect real-world biological invasions and the behavior of invasive species in a very interesting way. As biologists we'd love to see development team use their games as a means to draw attention to such problems, and the developers behind *Pokémon* has been doing that very gracefully (see the iconic case of Corsola in Salvador, 2019).

Although real phylogenetic (evolutionary) relationships don't seem to be valid among Pokémon, the combinations of different taxa give us the opportunity to imagine different paths real-world evolution could have taken. Fortunately, the crustacean Pokémon encompass several families of real crustaceans and reflect the great diversity of this group, though this is not often the case in the franchise (see Prado & Almeida, 2016, for an analysis on the arthropod diversity of Pokémon). We hope that other relevant groups of animals receive similar affection and attention: after all, Pokémon could very well ignite the spark of interest in the amazing biodiversity that surrounds us, especially for the younger generations.

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Daniel Cavallari is a zoologist and taxonomist who loves invertebrates, especially mollusks. He has been playing *Pokémon* since he was a kid, and does not intend to stop anytime soon.

Ana Vera-Silva is a former carcinologist and, despite not working in the field nowadays, wrote her master's degree dissertation about hermit crabs, and loves to study evolution and taxonomy in general. Used to love the *Pokémon* anime as a kid, but has a hard time trying to remember 'em all.

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The belligerent crustaceans of *Fight Crab*

Interview with Onuki Masafumi

Fight Crab is a new game by the indie studio Calappa Games[1] (aka Nussoft, Japan). As you might have suspected from the title, it revolves around crabs fighting each other. What you might not have anticipated, though, is that the crabs fight wielding over 40 different kinds of weapons, from swords and axes to chainsaws and light saber.

Given that this is the most innovative concept in fighting games since ever – and also a good display of crustacean biology – we just had to interview game developer Onuki Masafumi to uncover a little bit more about the game's behind-the-scenes story. Take a look below and see what we found out.

The premise *Fight Crab* is quite unusual. Where did you get your inspiration from? Was it some viral video on the internet, or some funny real-life story perhaps?

I've been making games with crabs fighting for 10 years, and I've seen videos of crabs holding knives.

Is there a 'story mode' in *Fight Crab*? If so, how do you tell a story about crabs?

The battle is their story. The campaign mode is driven by location staging and flavor texts.

[1] You can find it at https://www.neoaq.net/games-en/fightcrab/

The crabs have a very interesting selection of weapons at their disposal. What did you look for while choosing the weapons?

It's about having various shapes and functions. We focused on things that hit you directly, not shooting or magic.

We couldn't help but notice that there are 23 different types of crustaceans in your game. What were your criteria for choosing them? Are all of them real-world species?

All but one are real species. The selection criterion was that it had claws.

Can we expect to find some other amazing crustaceans besides crabs as well? A mantis shrimp, perhaps?

Mantis shrimp is present!

So, which crab species is your favorite?

Calappa.[2]

The design of the crabs is very detailed and realistic. Was there a concern about biological accuracy when designing the crab models?

I'm mainly concerned about not deforming the leg joints. There are six joints per leg, all actually moving.

Calappa calappa (Linnaeus, 1758), the smooth box crab or red-spotted box crab, from the Indo-Pacific. Image extracted from Wikimedia Commons (Hectonichus, 2013).

[2] *Calappa* is a genus of crabs belonging to family Calappidae, popularly known as 'box crabs' or 'shame-faced crabs', because its claws are held together to the body, as if the crab was hiding its face. There are over 40 living species in the genus *Calappa*, plus nearly 20 fossils (Ng et al., 2008; De Grave et al., 2009).

Calappa japonica Ortmann, 1892, the Japanese shame-faced crab, seen from above .Despite its name, it can also be found from Africa to Australia. Image extracted and cropped from Ng et al. (2011).

Did you get to study some crab science while making the game?

I haven't studied biology, but I gained knowledge through anatomy.

Typical fighting games have characters with two legs only. How difficult was it to animate all the legs of the crabs?

Rather, crabs don't have to worry about their center of gravity balance and their gait is more stable, which is easier than bipedal walking in a physics simulation environment.

By the way, why crabs versus crabs, and not crabs versus something else?

I prefer a fair fight on equal terms.

There are circa 7,000 species of crab in the world[3] and many are endangered and threatened with extinction, especially due to overfishing.[4] Real crabs can't use swords and chainsaws to protect themselves, so they depend on the goodwill of humans and public perception to survive. Do you think *Fight Crab* can make people realize how cool these critters are and maybe become a little more inclined to protect these creatures?

I hope so. I want them to aim for a sustainable fishery rather than aiming for a lot of money.

[3] Yeo et al. (2008); De Grave et al. (2009).

[4] For instance, see Orensanz et al. (1998) and Lizárraga-Cubedo et al. (2008).

If the crabs in *Fight Crab* could say something, what would they say?

Duel with me!

Last but not least, on which platforms can we play *Fight Crab*?

You can play it on Steam and Nintendo Switch.

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My light novel's title can't be this short! The evolution of light novel titles in another world!!!

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Light novels are a subculture of Japanese literature primarily targeting the young adult demographic, with the average length of 50,000 words, a dense publishing schedule, and usually illustrated with an anime/manga art style (Wikipedia, 2020). Due to their demographic, light novels are generally written in a simpler, more approachable fashion, and there is often an overlap between them and novels classified as young adult, middle grade, and children's literature. This is most evident when you find translated foreign novels, redesigned into a light novel style (English Light Novels, 2020).

Still, a more clear-cut definition of light novels has not yet been achieved, as they contain a lot of different features. Japanese literary critic Enomoto Aki, for instance, defined light novels as "entertaining literary work for readers in junior high school or high school", while the publishing house Nikkei Business Publications defines them as "books using anime pictures as covers and aimed at young readers" (Teipei Teen Tribune, 2020).

The term 'light novel' originated from "user participation" and was coined around 1990 by Kamikita Keita, the system operator of the Science Fiction and Fantasy forum in the Nifty Serve BBS (Saito, 2014). The light novel trend in juvenile novel markets was testified by the science fiction writer Ōhara Mariko in a book review for a newspaper in 1994 (Saito, 2016). Ōhara was impressed and confused with the increasing popularity of a group of novels referred to as 'light novels', one of the earliest examples of the use of this term (then still a neologism mostly restricted to online communities).

Figure 1: Cover of the light novel *Isekai Onsen ni Tensei shita Ore no Kounou ga Tondemosugiru* ("I was Reincarnated as a Hot Spring in an Alternate World, and I'm way too Effective"; Kadokawa, 2017): shallow or deep content? (Pun intended). Image extracted from MyAnimeList.

Ōhara's negative tone when using the term indicated her ambivalent position towards it, criticizing the proximity to manga for prioritizing characters over story, unrealistic settings, and shallow content (Fig. 1). She concluded that those works could not be

categorized as novels (shōsetsu) and should be only consumed as a passing entertainment that did not produce lasting emotional impact on the readers (Saito, 2016).

Light novels are an evolution of pulp magazines in Japan. In the 1970s, many pulp magazines began to put illustrations in their stories and included anime, movies and video game articles to cater to their audience. Arai Motoko, a science fiction and fantasy writer active mainly in the young adult market, is considered one of the harbingers of the breathless, chatty style of literature, typical of light novels (SFE, 2020). She is also credited with the popularization of the term 'otaku' in Japanese popular culture by using it in her works. Other famous work from this period is the heroic fantasy novel *Guin Saga*, by Kurimoto Kaoru, in continuous publication since 1979 (though the original author died in 2009, at which time this novel was the longest single-writer's work in the world).

Other very famous light novels (also in the West) are: *Record of Lodoss War* and *Slayers*, published in the 1980s, which contributed to the development of the fantasy and high fantasy genres in Japan; *Boogiepop* and *Full Metal Panic*, published in the 1990s, that mixed the action, fantasy and military themes with everyday student lives; the phenomenon *Haruhi Suzumiya*, published in 2003 and possibly a major turning point in the light novel and anime industry, by playing with the anime and manga tropes of the time, reflecting otaku culture, and being wildly popular on the Internet; and *Sword Art Online*, initially published as a web novel in 2002, that vastly contributed to the popularization of the 'isekai' genre (literally "different world", a genre that revolves around a normal person from Earth being transported to or reborn in another fantastical universe) – a commercially successful genre today, as seen in novels like *KonoSuba*, *Overlord* and *Re:Zero* (Fig. 2).

As argued by Saito (2015), with the participatory culture of the Internet, story writing became the major source of small narratives for its ease in creating consumable media content. While the *Haruhi Suzumiya* franchise mimics this participatory culture of the digital age, *Sword Art Online* was born out of the actual user participation in the creation and dissemination of the media content. The success of *Sword Art Online* has contributed to the creation of many write-your-own-fiction websites in Japan over the past years.

Figure 2: Isekai Quartet promotional art. A crossover show featuring characters from the popular isekai series *Overlord*, *Re:Zero*, *KonoSuba* and *The Saga of Tanya the Evil*. Image extracted from Wikipedia (Studio Puyukai, 2019).

A similar phenomenon was identified by Hansen (2016) with the 'cell phone novels' (or 'keitai novels'), that became a significant commercial success in Japan. Keitai novels also generated considerable literary criticism, but that had little impact on their continued success, which is presenting challenges not only to traditional critical interpretation of fiction, but also to the very manner that literature is created, disseminated and received. For an interesting analysis on the Japanese pop culture trends of fiction since the 2000s, with the popularization of themes like sekaikei ("end-of-the-world crisis"), sabaibukei ("survival"), and nichijōkei ("slice of daily life"), refer to Tanaka (2014).

GOD'S BLESSING ON THESE WONDERFUL LIGHT NOVELS

A very peculiar feature of light novels is their titles. The titles are (in)famous for being unusually long, often composed of large sentences that give a summary of the plot, interjections, and filled with excessive punctuation marks such as exclamation and interrogation marks (Fig. 3). An article from the satirical anime news website Anime Maru, even joked about the possibility of the release of a light novel composed solely of a 196-page-long title (Anime Maru, 2016).

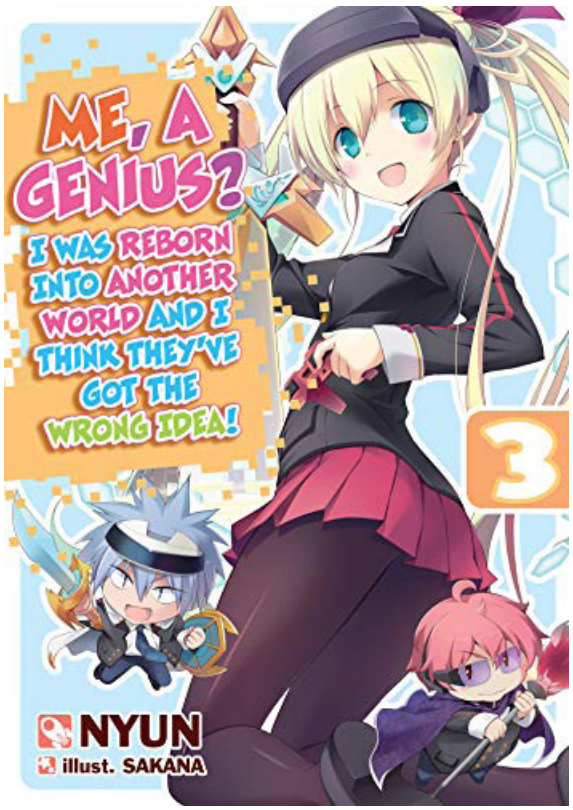

Figure 3: Cover of the light novel *Me, a Genius? I was Reborn into Another World and I think they've got the Wrong Idea!* (J-Novel Club, 2018). One can only wonder what the plot for this light novel entails. Image extracted from MyAnimeList.

Two analyses of the increase in the size of light novel titles have been done in the past. The first one was conducted by Twitter user @GenreCodeLovers, who compiled a list of light novel titles from the website Ranobe Mori and analyzed the number of Japanese characters (apparently not corrected for polysyllabic kanji) in them (reported by Parker-Dalton, 2019). The second one was made by YouTuber Red Bard (2019), who compiled a list of English titles from the website MyAnimeList and counted the number of words, in order to identify the moment in which titles became so long. She concluded that the movement started between 2009 and 2013, but really caught on in 2014.

The objective of the present work is to expand on those studies, following a more structured and scientific protocol and analyzing results via statistical tests. Using the original Japanese titles, we will evaluate the progression in title size by counting the number of characters. In addition, we will try to identify whether the larger title sizes are related to the novels' literary genre. Finally, we will identify which are the most common themes and words among the titles.

LIST ART ONLINE – BUILDING A LIST OF LIGHT NOVELS

Our light novel list was composed from two complementary online sources: the website English Light Novels (https://englishlightnovels.com/list-of-light-novels-alphabetical/) and Wikipedia (https://en.wikipedia.org/wiki/List_of_light_novels). While the titles acquired from the former website were restricted to novels officially published in English, Wikipedia listed all titles (regardless of publication in English) that have their own Wikipedia page (mostly due to having a sufficiently successful anime or manga adaptation).

For each title, we extracted the following information:

- Original title of the light novel, in the Hepburn Romanized form. For almost all cases, the Romanized form was provided by the website itself. In case this information was not available, we searched for a Romanization in either Baka Updates (https://www.mangaupdates.com/) or MyAnimeList (https://myanimelist.net/). Whenever the titles contained words originally in English, they were left unchanged (katakana forms of foreign words, however, were Romanized as usual). Punctuation was

also left unchanged.

- Translated title of the light novel to English. Whenever the light novel was formally released in English, the official title was used. Otherwise, a literal translation was used.

- Year of publication (in Japan) of the light novel's first volume (or the year the first chapter was published online, in the case of web novels).

- Genre(s) of the light novel. For most novels, the list of genres was provided by the two websites mentioned above; otherwise, they were obtained from MyAnimeList.

The list was compiled on August 9th, 2020, and had a total of 498 different titles.

From those, we distinguished titles that were not originally light novels. For instance, light novels based on a manga (e.g., *Attack on Titan* and *Death Note*), anime (e.g., *Eureka Seven*, *Anohana*, *Sarazanmai*), OVA or movie (e.g., *FLCL*, *The Boy and the Beast*, and those by Makoto Shinkai), video game or visual novel (e.g., *Kingdom Hearts*, *Danganronpa*, *Higurashi*, and the *Fate/Stay Night* franchise). Also, we distinguished the original novels from sequels, side stories or spin-offs, such as *The Reprise of the Spear Hero* (from the *Shield Hero* series), *Is It Wrong to Try to Pick Up Girls in a Dungeon? On the Side: Sword Oratoria* (side story of the *Danmachi* light novel), *Wolf and Parchment: New Theory Spice and Wolf* (sequel of *Spice and Wolf* light novel). After this, we concluded that 406 out of the 498 listed titles were original light novels, while the remaining 92 were not.

Re:SULTS – STARTING AN ANALYSIS IN THIS ARTICLE

For our analyses, we used only those 406 light novels that were original titles. Since many of the novels that were sequels or spin-offs included the title of the original novel in their own titles (e.g., *Is It Wrong to Try to Pick Up Girls in a Dungeon? On the Side: Sword Oratoria*) and thus, were naturally longer, they would have biased the analyses.

Firstly, we evaluated how the average number of characters in the title changed from year to year. For this analysis, we used the original Japanese title in romanized

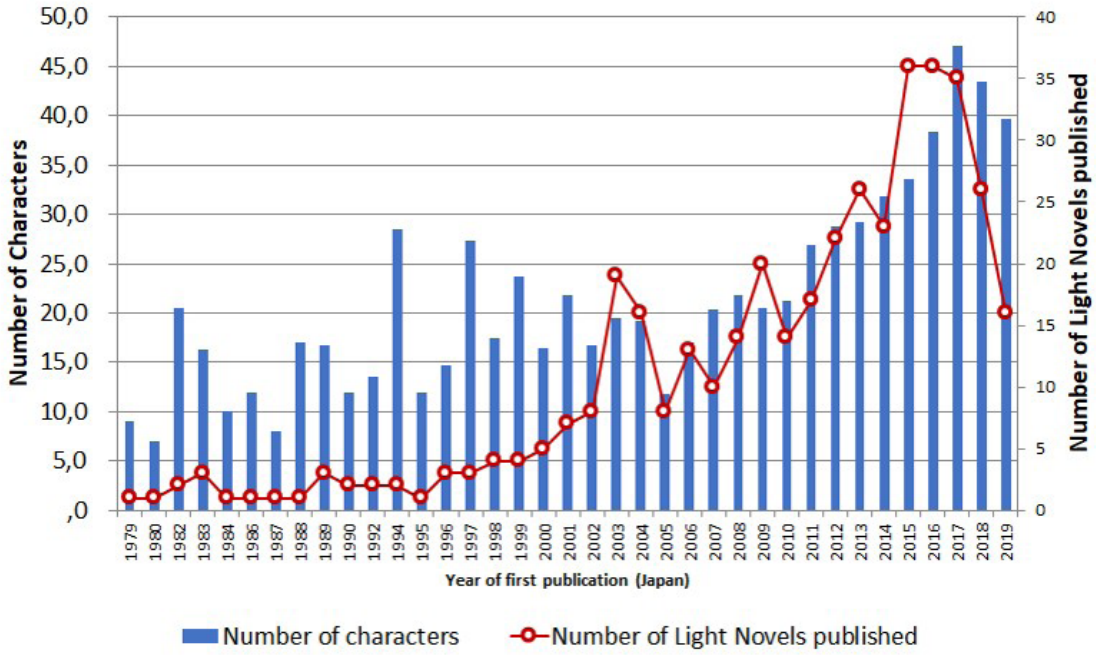

Figure 4: Average number of characters from the novels' titles, and number of light novels published per year, considering only "original" novels.

form, also including any punctuation and spaces, and considered the year of the novels' first publication in Japan. The results can be seen in Figure 4.

From this first analysis, we can clearly see an increase in the number of novels published and a clear increase in the average number of characters since the late 1970s. The years of 2018, in particular, had a whooping average of over 45 characters per title. The longest title award, though, goes to the R18 novel published in 2016 *Yami Zokusei no Mahoutsukai daga, naze ka Yuusha ni Natte Shimatta ~Sore wa Tomokaku Yome ni Ii Kurashi wo Saseru Tame ni Ganbatte Nariagarou to Omou*, or "Busy Wizard: This Warlock Just Wants to Provide for his Wives!" (Fig. 5).

In order to identify the precise year when the increase in title length started, we used a continuous piecewise linear model, popularly referred to as broken-stick model. In regression models, it is often assumed that the regression function has the same parametric form throughout the domain of interest. However, it might be possible that a regression function is composed of a sequence of submodels, that is, multiple linear segments (Das et al., 2016). The segments can form a continuous function, but with discontinuities in slope at "transition points" between each segment.

It is relatively easy to fit the segmented curves when it is known in advance where each transition point is. When the transition points are unknown, as in our case, the problem becomes more difficult and we need to use the data to estimate where the transition points are. Hudson (1966) developed an algorithm to obtain the best fit iteratively. With a large number of transition points, this iterative procedure can be very complex, but as we are assuming the existence of a single point (that is, a specific year when the trend started), it is much simpler to proceed testing every point for the best fit for the method of least squares.

Figure 5: Cover of *Yami Zokusei no Mahoutsukai daga, naze ka Yuusha ni Natte Shimatta ~Sore wa Tomokaku Yome ni Ii Kurashi wo Saseru Tame ni Ganbatte Nariagarou to Omou* (Panty Press, 2018; yes, that's the name of the publisher), our wordiest title, and probably the lewdest novel in our list as well. Image extracted from Goodreads.

After applying this procedure in our data, we see two possible transition points with the same fit: 2004 and 2010 (Fig. 6). Looking at the results, with the error bars for each year, we can see that until 2010, the average number of characters per title changed very little – one could say that it almost remained unchanged, considering the error bars – but that an increase is very noticeable after 2010. The transition point in 2004 being a good fit, though, is most likely due to 2005 being an outlier with some very short titles (including the shortest one in our list, the yaoi novel Esu or S, Fig. 7). Thus, it is more likely that the transition point is truly 2010. This result is aligned with the one estimated by YouTuber Red Bard (2019), who eyeballed the start of this trend between 2009 and 2013.

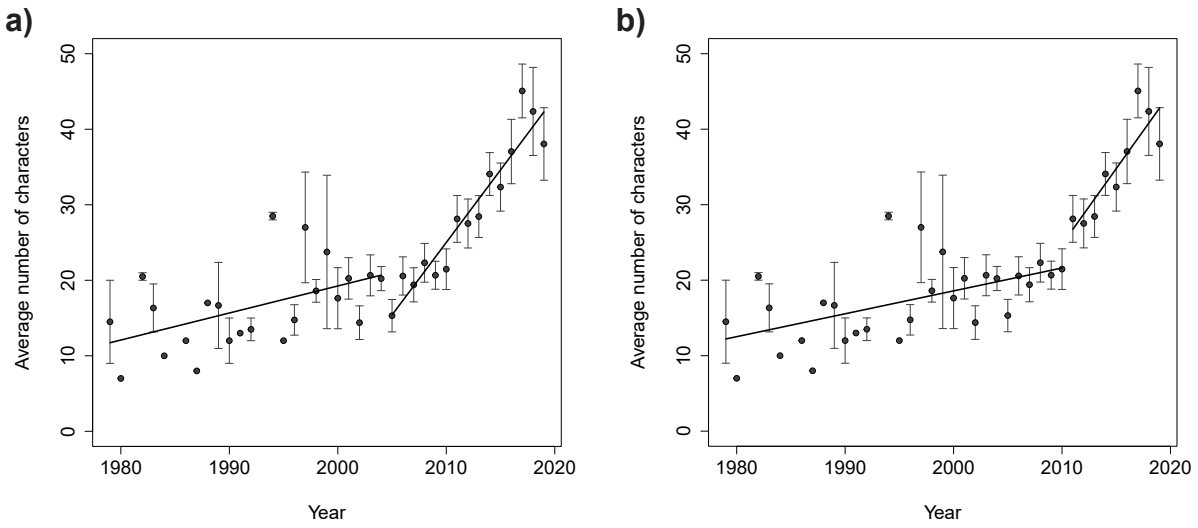

Figure 6: Results of the broken-stick model with a) the transition point in 2004; and b) the transition point in 2010.

Figure 7: Cover of Esu (Taiyoh Tosho, 2005), the novel with the shortest title in our list. Image extracted from Wikipedia.

NO GENRE, NO LIFE

To analyze how the genre of the light novels affected the expected number of characters of the title, firstly we identified the 10 most "popular" genres, that is, the ones with the largest number of novels. The ten most popular genres were: fantasy; comedy; romance/romcom; action; adventure; isekai/virtual reality; drama; science fiction; harem; and mystery. One could argue that some of these are not really literary genres, such as isekai or harem (and one would most likely be right according to most literary experts), but given the source material at hand, we obviously had to consider them.

Table 1: Average number of characters in the title per genre.

Genre	Average Number of characters	Number of Titles
All	28.990	406
Fantasy	33.079	215
Comedy	31.421	152
Romance / RomCom	27.291	127
Action	26.565	92
Adventure	27.679	84
Isekai / Virtual Reality	39.329	82
Drama	24.075	67
Sci-fi / Science Fiction	23.782	55
Harem	30.221	68
Mystery	21	26

Once the "most popular" genres were defined, we calculated the average number of characters per title for each genre. The results are shown in Table 1.

From the results in Table 1, we can see that the wordiest titles are by far in the isekai genre, followed by fantasy. This was not really a surprise, considering how many of the longest titles were classified as isekai or fantasy, as seen in the longest titles (Table 2).

Table 2: List of the top longest novel titles.

English Name	Japanese Name	Year of first publication	Genres	Nr characters
Busy Wizard: This Warlock Just Wants to Provide for his Wives!	Yami Zokusei no Mahoutsukai daga, naze ka Yuusha ni Natte Shimatta ~Sore wa Tomokaku Yome ni Ii Kurashi wo Saseru Tame ni Ganbatte Nariagarou to Omou	2016	R18, Fantasy, Ecchi, Harem	149
ROLL OVER AND DIE: I Will Fight for an Ordinary Life with My Love and Cursed Sword!	Omae Gotoki ga Maou ni Kateru to Omou na' to Gachizei ni Yuusha Pāti wo Tsuihou Sareta node, Outo de Kimama ni Kurashitai	2018	Action, Fantasy, Horror	121
A Mysterious Job Called Oda Nobunaga	Oda Nobunaga to Iu Nazo no Shokugyou ga Mahou Kenshi yori Chīto Datta node, Oukoku o Tsukuru Koto ni Shimashita	2017	Fantasy, Kingdom Building	111
Banished from the Hero's Party, I Decided to Live a Quiet Life in the Countryside	Shin no Nakama ja Nai to Yuusha no Pātī wo Oidasareta node, Henkyou de Surō Raifu suru Koto ni Shimashita	2018	Fantasy, Comedy, Romance	104
I'm a Behemoth, an S-Ranked Monster, but Mistaken for a Cat, I Live as an Elf Girl's Pet	S-ranku monsutā no "Behīmosu" dakedo, Neko to Machigawarete Erufu Musume no Pet toshite Kurashitemasu	2018	Adventure, Ecchi, Isekai, Comedy	101
Woof Woof Story: I Told You to Turn Me Into a Pampered Pooch, Not Fenrir!	Wanwan Monogatari: Kanemochi no Inu ni Shite to wa Itta ga, Fenriru ni Shiro to wa Itte Nee!	2017	Isekai, Fantasy, Comedy	92
Suppose a Kid From the Last Dungeon Boonies Moved to a Starter Town	Tatoeba Rasuto Danjon Mae no Mura no Shōnen ga Joban no Machi de Kurasu Yō na Monogatari	2017	Adventure, Fantasy	88
My Instant Death Ability is So Overpowered, No One in This Other World Stands a Chance Against Me!	Sokushi Chīto ga Saikyou Sugite, Isekai no Yatsura ga Marude Aite ni Naranai n Desu ga	2016	Isekai, Fantasy, Adventure, Comedy	86

Table 2 (cont.)

Middle-Aged Businessman, Arise in Another World!	Around 40 Eigyou-man, Isekai ni Tatsu!: Megami Pawa de Jinsei Nidome no Nariagari	2017	Isekai, Slice-of-Life, Fantasy	81
Mapping: The Trash-Tier Skill That Got Me Into a Top-Tier Party	Hazure Skill "Mapping" wo Te ni Shita Shounen wa Saikyou Pātī to Danjon ni Idomu	2018	Fantasy, Adventure, Action	80
If It's for My Daughter, I'd Even Defeat a Demon Lord	Uchi no Musume no Tame Nara-ba, Ore Moshikashitara Maou mo Taoserukamo Shirenai.	2015	Fantasy, Adventure, Slice-of-Life	79
My Next Life as a Villainess: All Routes Lead to Doom!	Otome Gēmu no Hametsu Fu-ragu shika nai Akuyaku Reijou ni Tensei shite shimatta…	2015	Comedy, Video Game Isekai, Romance, Otome	79
I've Been Killing Slimes for 300 Years and Maxed Out My Level	Suraimu Taoshite Sanbyaku-nen, Shiranai Uchi ni Reberu Makku-su ni Nattemashita	2017	Comedy, Isekai, Fan-tasy, Slice-of-Life	78
Of Dragons and Fae: Is a Fairy Tale Ending Possible for the Princess's Hairstylist?	Kamiyuishi wa Ryuu no Tsugai ni Narimashita (Yappari Machigai Datta Sou Desu)	2019	Fantasy, Romance	77
Can Someone Please Explain What's Going On?!	Dareka Kono Joukyou wo Setsu-meishite Kudasai!: Keiyaku kara Hajimaru Uedingu	2013	Fantasy, Romance, Shoujo	76
The White Cat's Revenge as Plotted from the Dragon King's Lap	Fukushuu wo Chikatta Shironeko wa Ryuuou no Hiza no Ue de Damin wo Musaboru	2016	Isekai, Shoujo, Romance	75
Ascendance of a Bookworm: I'll Do Anything to Become a Librarian!	Honzuki no Gekokujou: Shisho ni Naru Tame ni wa Shudan wo Erandeiraremasen	2015	Isekai, Fan-tasy, Drama	74
Do You Love Your Mom and Her Two-Hit Multi-Target Attacks?	Tsujo Kogeki ga Zentai Kogeki de Ni-kai Kogeki no Okasan wa Suki desu ka?	2017	MMO Isekai, Com-edy, Fantasy	73
Seriously Seeking Sister! Ul-timate Vampire Princess Just Wants Little Sister; Plenty of Service Will Be Provided!	Tonikaku Imouto ga Hoshii Saikyou no Kyuuketsuki wa Mu-jikaku Gohoushichuu	2018	Yuri, Com-edy, Fantasy	73
WorldEnd: What Do You Do at the End of the World? Are You Busy? Will You Save Us?	Shuumatsu Nani Shitemasuka? Isogashii desuka? Sukutte Mor-atte Ii desuka?	2014	Drama, Romance, Fantasy	72
My Mental Choices are Completely Interfering with my School Romantic Com-edy	Ore no Nōnai Sentakushi ga, Gakuen Rabu Kome o Zenryoku de Jama Shiteiru	2012	Comedy, romance, slice of life	72

Due to the expected intersection between the fantasy and isekai genres, we excluded isekai novels from our analysis, expecting a sharp decrease in the title length of fantasy novels (Table 3). However, the fantasy genre remains the one with the longest titles, dropping from an average of 33.1 characters in the title to 31.2. The comedy and adventure genres, though, were the ones most affected by the removal of isekai novels (respectively, decreasing from 31.4 to 26.8, and 27.7 to 23.7 characters), hinting that a larger number of characters in isekai novels' titles might be related to a more comedic tone (Table 3).

Table 3: Average number of characters in the title per genre, excluding isekai novels.

Genre	Average Number of characters (no Isekai)	Number of Titles
All	26.373	324
Fantasy	31.167	156
Comedy	26.783	120
Romance / RomCom	26.593	118
Action	25.272	81
Adventure	23.7	60
Drama	23.317	63
Sci-fi / Science Fiction	22.54	50
Harem	28.118	51
Mystery	21	26

IS IT WRONG TRYING TO PICK UP CONCLUSIONS IN THIS ARTICLE?

To identify some common themes in light novel titles, we used an online word cloud generator (Davies, 2018) to highlight the most common words used in the titles, in both English and Japanese (Fig. 8).

By looking at the word clouds, the presence of the fantasy and isekai themes is evident in both languages. It is easy to identify words related to (1) a magical setting, such as: magic (mahou in Japanese), magical (majutsu, more literally 'magical arts'), witch (majo); (2) words related to dungeons & to dragons: dungeon (danjon), monster (monsuta), demon (maou), alongside elf and vampire in English translations of the titles, and megami (goddess) in the original Japanese titles; (3) words related to medieval settings, such as: princess (hime), hero (yuusha), alongside king and knight in English translations of the titles; and, finally, (4) words directly related to the isekai concept, such as: another and world (typically used in tandem), reborn, reincarnated in English and sekai (world), isekai (another world), tensei (reincarnation) in Japanese. It is important to note that the titles of isekai novels sometimes have those specific words as a self-referential joke or parody, thus skewing this word cloud.

Other very common themes are school settings. This includes the words school (gakuen) and words related to girls/women in general (considering that the majority of the audience is expected to be male teenagers and young adults). The latter includes the

Figure 8: Word clouds with the most common words in light novel titles: a) English titles; b) Japanese titles.

words girl and sister in English titles, but is more varied in Japanese: musume (daughter), otome (maiden), imouto (younger sister), kanojo (girlfriend), and shoujo (girl).

Figure 9: Light novels can have their whole title written in their spine, as well as specific and easily recognizable colors to make them easy to find. Image extracted from English Light Novels.

From our analyses, we can conclude that the increase in the length of light novel titles is a true phenomenon that can be observed statistically. Light novels, as argued by Saito (2016), successfully bridged the increasing gulf between the expanding visual media and the conventional print media, having a very strong market in Japan, which is very competitive, where successful novels can have manga and anime adaptations, while successful anime and manga can have light novel prequels, sequels and spin-offs. It is possible that in order to survive in that market, publishers opt to invest in increasingly larger titles, in order to draw the reader's attention and immediately inform them about the genre and content of the light novel through the book's spine alone (Fig. 9), while also investing in colorful and appealing covers.

Thus, the increase in title sizes is a somewhat recent phenomenon. So, for now, let's observe how this trend develops, while hoping for a new *Konosuba* anime season.

WOLF AND REFERENCES: OLDER THEORY SPICE AND WOLF

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About the author: The melancholy of João Tomotani

My name is **João Tomotani**, my calling is that of a Mechanical Engineer, the strongest of all Engineers. First off, I'm not interested in ordinary people. But, if any of you are aliens, time-travelers, or espers, please come see me. That is all!

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Ancient Egyptian royalty in *Fate/Grand Order*

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Fate/Grand Order, and the *Fate* franchise in general, is probably something all historians, archaeologists and literature scholars at large curse every time they do a Google Search for a historical figure or famous literary character. For instance, just google 'Astolfo' and there's a good chance that the first result you'll get is the character from *Fate* and not the original one from the *Matter of France*. But how can a reincarnation of a character in a Japanese game supersede the original?

It all started in 2004 with *Fate/stay night*, a computer game. More accurately, an eroge (エロゲ). It quickly developed into a franchise, with the first manga and anime appearing in 2006 and excluding the 18+ portion of the original game. Afterwards, more games, anime and all sort of merchandise made *Fate* increasingly prominent in Japan. And then, *Fate/Grand Order* happened.

Fate/Grand Order (henceforth FGO) is a video game developed by Delightworks (mobile version, released in 2014) and Sega AM2 (arcade version, 2018). It is a huge hit in Japan and the top-grossing mobile game in the country. Worldwide, it has grossed more than 4 billion US dollars (ca. 80% from Japanese players alone), being on par with Niantic's *Pokémon Go* (SuperData, 2019; Chapple, 2020). Just to put it into perspective, FGO is available in very few countries outside Japan, while *Pokémon GO* is a global phenomenon. And what's more, FGO has for the past two years been the dominating game in numbers of tweets, beating the likes of *Fortnite* (Park, 2020).

The main idea of the series is that combatants fighting for the Holy Grail can summon powerful allies to help them. The combatants are known as 'Masters', while the summoned allies are known as 'Servants'. The Servants are historical, mythological or literary figures, extracted from various cultures around the world.[1]

In this article, I'll give historical and archaeological background to those Servants extracted from Ancient Egypt. Why? Well, firstly, because I love Ancient Egypt and I think it is not as widely discussed as I would like it to be. Secondly, because those characters are a tad more obscure than the usual Servants[2] and deserve more time in the spotlight.

A QUICK PRIMER TO ANCIENT EGYPT

Ancient Egypt, as a recognizable distinct entity, lasted for around 3,000 years. That is a lot of time and Egypt went through several different periods during its existence. *Fate* characters were taken from different periods and we need to put that into perspective. So, let's start by taking a look

[1] Note that some Servants are gender-bent female versions of the original figures to cater to a predominantly straight male audience.

[2] That is, Saberfaces.

at the table below (compiled from Shaw, 2004), showing each period and its start and end dates.

Period	Dynasties	Date
Predynastic Periods (Neolithic)	–	5300–3000 BCE
Early Dynastic Period	1–2	3000–2686 BCE
Old Kingdom	3–8	2686–2160 BCE
First Intermediate Period	9–11	2160–2055 BCE
Middle Kingdom	11–14	2055–1650 BCE
Second Intermediate Period	15–17	1650–1550 BCE
New Kingdom	18–20	1550–1069 BCE
Third Intermediate Period	21–25	1069–715 BCE
Late Period	25–"31"	715–332 BCE
Macedonian Era	–	332–304 BCE
Ptolemaic Era	–	304–30 BCE
Roman Era	–	30 BCE – 395 CE
Byzantine Era	–	395–641 CE
Arab conquest	–	641 CE

When people think about Ancient Egypt, the first image that will come to mind will likely be the pyramids. The "classic" trio of pyramids of Giza was built during the 4th Dynasty, in the Old Kingdom. But in spite of that being a rather early stage of Ancient Egypt, many people associate pyramids with later events, especially with the times of two of the most famous Pharaohs: Ramesses II and Cleopatra VII. Ramesses II (sometimes spelled Rameses or Ramses), known as Ramesses the Great, belongs to the 19th Dynasty — therefore, to the New Kingdom. That is over 1,200 years after the pyramid-builders of the 4th Dynasty. Cleopatra VII (the famous Cleopatra) ruled during the Ptolemaic Period, the final one before Roman conquest. Again, almost 1,200 years after Ramesses II.

That means many people imagine Ancient Egypt as a hybrid of distinct periods, as if 3,000 years of history were a homogenous thing. So please keep that idea of different periods and times in mind while you read.

THE SERVANTS

I won't go through a detailed explanation of Servants here; I'd rather keep things simple for this article and focus on the Ancient Egypt part of FGO. In any event, if you're reading this, you probably know your stuff already. Suffice to say Servants are RPG characters: they have character classes (Archer, Lancer, etc.) with Pokémon-like effectiveness against one another, and they even have Dungeons & Dragons alignments. Their special attack is called Noble Phantasm (ノウブル・ファンタズム). When summoned, Servants usually appear in a form that represents their "golden age" or the "prime of their lives" (TYPE-MOON Wiki, 2020). If you want to know more about Servants in the *Fate* franchise, take a look at the TYPE-MOON Wiki; for more specific information about Servants in FGO (game stats, etc.), see the Fate/Grand Order Wikia.

Now let's go to the Egyptian Servants, in chronological order. For the section below, I am drawing information from numerous published academic sources. I won't cite them all in the text as usual, because that would impair the reading with loads of references. But I point out the main sources for further reading in case you want to learn more about any given topic. All other sources are listed further below in the References section.

I'll focus exclusively in what is represented in FGO; otherwise, this article would become longer than my doctoral thesis. But I will bring in tidbits from other corners of the Fateverse every now and then, when it's

appropriate for the discussion. If you're a devout fan of the franchise, please forgive me if I fail to mention some piece of information from sources other than FGO[3].

Nitocris

Nitocris, stages 2 and 3. Art by Shima Udon.

Nitocris (or Nitocret) was once thought to be the last Pharaoh of the 6th Dynasty and hence, of the Old Kingdom (around 2,180 BCE), before Egypt fell into the troubled times of the First Intermediate Period. Her name appeared in the works of Manetho (a priest who compiled the *Aegyptiaca*, a list of Egyptian kings, during the 3rd century BCE) and Herodotus (the famous Ancient Greek historian). However, her name never appeared in any pre-Manetho Egyptian source and she became somewhat of a legendary figure, with archaeologists hotly debating her existence.

It is now known that the last Pharaoh of the 6th Dynasty was actually Netjerkare Siptah (also spelled as Neitiqerty Siptah), a male king. His name was misread in fragmentary sources and that mistake gave rise to the legendary Nitocris. You can find the full story in the work of Ryholt (2000).

Although there is no arguing with evidence, that revelation is quite a bummer, depriving the world of a cool mysterious female Pharaoh. By the time the *Fate* franchise began, it was already known (at least in academia) that Nitocris was not a historical person. The game, however, indicates her origin in historical fact, clearly following outdated academic literature. In any event, her non-historical status wouldn't prevent Nitocris from appearing in *Fate*, since the franchise is famous for another legendary ruler of dubious historicity.

In FGO, Nitocris appear with an Ancient Egyptian-inspired outfit and jewelry, with the exception of the weird choice of platform shoes. She carries a *was*-scepter, which is often seen held by pharaohs and represents power and dominion. That scepter usually consists of a long vertical shaft with a forked base and is surmounted by an animal head, so Nitocris' scepter is spot-on. Nitocris belongs to the Caster class, so the idea of her carrying a staff also fits with staple fantasy spellcasters.

A was-scepter made of faience; Nubia, Late Period (center portion restored). The animal head represents the god Set. Photo by Joan Lansberry 1995–2012; image extracted from http://www.joanannlansberry.com.

Given the prominence of kemonomimi[4] in Japanese pop culture, Nitocris is shown with a pair of Anubis-like ears on top of her head, though the game mistakenly considers it an attribute of Horus. In later ascension stage, Nitocris' hair is banded in dark blue and golden and thus becomes reminiscent of the *nemes* headdress used by pha-

[3] I'll try writing about those in the future.

[4] Kemonomimi (獣耳) literally means "animal ears" and denotes an anime/manga character with, well, animal ears. Other features such as a tail and fangs might also be present.

raohs. Finally, Nitocris has red facial paint, which is a little weird at first sight. There is some evidence of rouge-like facial paint from reliefs (and also items found in tombs), but we don't know the exact usage of it or how pervasive it was. Curiously, though, Manetho stated in his *Aegyptiaca* (known to us just from later authors and translations) that Nitocris was the noblest and loveliest of all women, of fair complexion with red cheeks. Could her character designer have read Manetho's work?

The golden mask from Tutankhamun's mummy "wears" a *nemes* headdress; Valley of the Kings, 18th Dynasty, New Kingdom. Photo by Ibrahim.ID & D. Levy (2014, 2015); image extracted from Wikimedia Commons.

Nitocris' designer, Shima Udon, actually commented that he "crammed a bunch of Egyptian-like symbols on her" and considered that he "completed the design in a simple and well-coherent manner" (TYPE-MOON Wiki, 2020). And that is surprisingly the case. He also said that Nitocris' Stage 3 design came from a draft by the director, which had much more skin exposure than his original take.

In the game, Nitocris is Lawful Good, which is consistent with a pharaoh (see the discussion of Ozymandias below), and is known as "Avatar of the Sky", possibly a reference to the idea of the pharaoh being an incarnation of Horus, god of kingship and the sky (see also Salvador, 2016).

Nitocris' Noble Phantasm is called "Anpu Neb Ta Djeser" (translated as "Nether Mirror Thesaurus" or "Nether Mirror Canonical Text" in the franchise). It features Anubis and a large mirror that spills out evil spirits onto Nitocris' enemies. That has absolutely nothing to do with Ancient Egypt. Rather, it is taken from a short story called "The Mirror of Nitocris" by horror writer Brian Lumley, who portrays Nitocris as an evil vengeful queen. Lumley wrote in the Cthulhu Mythos of H.P. Lovecraft, who had previously portrayed Nitocris as an evil queen.[5]

Nitocris (Assassin) (Stages 1 and 2). Art by Shima Udon.

There is also a version of Nitocris that belongs to the Assassin class, which was available for a limited time during a special event in the game. In her Stage 1, she wears the cartoon ghost-like garb of the god Medjed, with his characteristic eyes — though her Anubis-like ears remain visible. Medjed, also known as "The Smiter", is a unique figure in Ancient Egyptian mythology and art, being instantly recognizable. I won't go into further detail about Medjed here, since I already dedicated an entire article to his

[5] I'd wager that's just the typical misogyny of Lovecraft, but I confess I didn't read the stories where she appears and can't be made to read anything else written by him.

origins and how Japanese pop culture embraced him (Salvador, 2017); so, consider yourself invited to read it. He is also present in Nitocris' attack animations in FGO (in both Assassin and Caster incarnations), shooting beams from his eyes as usual.

Close-up of Sheet 76 of the Greenfield Papyrus showing Medjed. See if you can spot him! Image retrieved from Salvador (2017), courtesy of the British Museum, ©Trustees of the British Museum.

In her Assassin guise, Nitocris' Noble Phantasm is called "Sneferu Iteru Nile". It has been translated as "Cleanse the impurities, blue and beautiful Nile" in FGO, but it is just the words Sneferu (first pharaoh of the 4th Dynasty), Iteru ('river' in Ancient Egyptian, used to refer to the Nile), and Nile arranged in tandem, with no special meaning whatsoever. This special move is a reference to a story mentioned by Herodotus in his *The Histories* (4th century BCE) in which Nitocris avenged the deaths of her brother[6] and her husband by diverting the Nile to drown the murderers. It is also a water-based special attack, which ties in with her "summer swimsuit" outfit theme.

Ozymandias

As with Nitocris above, FGO went with the Greek name for this character. Ozymandias is none other than Ramesses II, or Ramesses the Great, that I mentioned above. Arguably one of the greatest pharaohs, Ramesses II was the third ruler of the 19th Dynasty in the New Kingdom; he reigned for 66 years in the 13th century BCE and lived to be 90 years old. He led numerous military campaigns to the Near East in the north and to Nubia in the south, and also established several treaties with neighboring nations.

Ozymandias (Stage 3). Art by Nakahara.

Ramesses II was named after his grandfather; nine other pharaohs were named after Ramesses the Great (all belonging to the 20th Dynasty), a record among Egyptian rulers. He had two principal wives, Nefertari (more on her later) and Isetnofret, and six other great royal wives. According to most counts, Ramesses fathered around 90 to 100 children; this fact is alluded to in FGO, though they preferred to go with the more dramatic figure of "over a hundred".

He was also a prodigious builder and during his reign numerous temples, monuments and even cities were built, a fact also mentioned in FGO. In all likelihood, Ramesses was trying to outdo Amenhotep III, the Pharaoh from the 18th Dynasty known as "The Magnificent". The reign of Amenhotep III is considered the Golden Age of Egypt.

Most notably, he built the city of Pi-Ramesses (or Per-Ramesses) in the region of the Nile Delta to be the new capital. The

[6] Her brother is mentioned a few times in FGO, but doesn't appear as far as I'm aware. But I missed the Assassin event.

name means "House of Ramesses", so we can have an idea of how much he must have loved himself (a feature that is also shown in FGO). He also built a gigantic temple complex in Thebes known as Ramesseum. As his mortuary temple, the Ramesseum was a place to worship the deceased pharaoh and keep his memory alive for eternity.

Unfortunately, not much remains of the Ramesseum today. Image extracted and modified from Wikimedia Commons (Steve F-E-Cameron, 2010).

Façade of the Great Temple at Abu Simbel, with four colossal statues representing Ramesses II; public domain.

And now to FGO. The game informs the players that Ozymandias is also known as Ramesses II and as Meryamen. The full royal titulary of pharaohs consisted of five names. The first name is called the Horus name. The second one is the Nebty name or Two Ladies name, indicating that the pharaoh was the lord of the two lands (Upper and Lower Egypt). Then there's the Golden Horus name, possibly signifying the pharaoh's eternal name. Then there's the throne name (*prenomen*), which is the regnal name. And finally, there's the personal name (*nomen*), the name given at birth. Pharaohs are typically known to us by their personal name (followed by Roman ordinals, as standard for kings). The last two names are written inside a symbol called 'cartouche'. The throne name of Ramesses II was Usermaatre Setepenre; note that Ozymandias is the Greek rendition of the first part of this name. His personal name was Ramesses Meryamun (or Meryamen).

Cartouche with Ramesses's name, from a statue of Ra-Horakhty in the British Museum. Image extracted from Wikimedia Commons (Jl FilpoC, 2019).

Ozymandias' alignment is given as Chaotic Neutral in FGO. That is just wrong. A Pharaoh's duty was to protect Egypt and its people from Chaos and to uphold *maat*, which is the Ancient Egyptian concept of truth, harmony (in the sense of balance or order), morality and justice. As I mentioned on my article about *Overwatch*'s Pharah (Salvador, 2016), a Pharaoh, and especially one such as Ramesses II, should unquestionably have a Lawful alignment. For more about pharaohs, their names, and their daily life at home or in battle, see Partridge (2002) and Shaw (2012).

The character design of Ozymandias failed to take into account one piece of in-

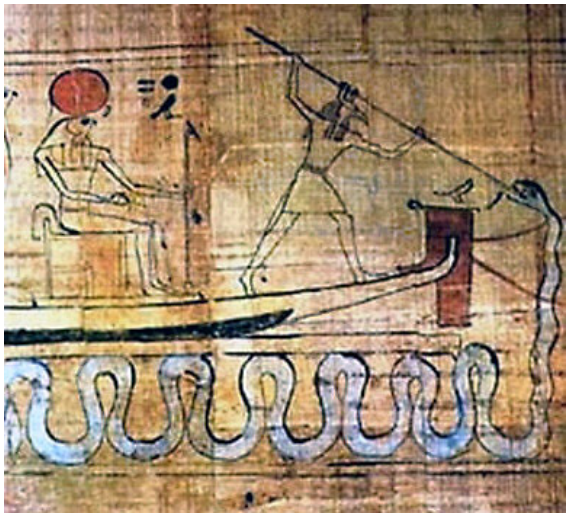
formation that is a favorite of the public: Ramesses was a redhead. We know that because of his mummy. His FGO incarnation is dark-haired, though I'll venture saying it is better this way. Now let's turn to Ozymandias' outfit: it is completely absurd. Okay, that's done. Next topic: eye make-up. Ozymandias (and also Nitocris, see above) uses the dark eyeliner that's typical of Ancient Egypt since Predynastic times. The cosmetic is called kohl and was made by grinding sulfide-based minerals. It was worn by men and women and besides being fashionable, it supposedly protected the eye from the brunt of ultraviolet (UV) light, but that is still debated in academia. Kohl produced with galena (lead sulfide) could supposedly be toxic if absorbed by the skin, but this is also still hotly debated by researchers. Last but not least, new research points out that applying kohl might lead to an increase in the production of nitric oxide by the body, which is an antimicrobial agent (Mahmood et al., 2019).

Pharaoh Tutankhamun's canopic coffinette (that held mummified internal organs like the liver); Valley of the Kings, 18th Dynasty, New Kingdom. Note the crook/heka with blue and golden stripes, like the one held by Ozymandias in FGO. Photo by D. Denisenkov (2012); image extracted and modified from Wikimedia Commons.

Ozymandias carries a crook (like a shepherd's staff), with golden and blue stripes. The crook (called *heka*) and the flail (*nekhakha*) were the symbols of Osiris, god of the underworld, but they also signified royal authority. So, it's appropriate that Ozymandias carries one. He attacks using solar beams; if you consider that together with his staff, you'd expect him to belong to the Caster class. That's not the case, though.

His class is Rider, which is defined as a "mounted knight" or heroes capable of taming "any beast, be it mythical or mechanical". The reason for Ozymandias being a rider is not apparent in FGO. At first it could be suspected that this choice was due to the prominent usage of chariots in Egyptian military in that time. However, he qualifies as a Rider due to his Noble Phantasm (not in FGO, see below) Mesektet, the Solar Barge. The Solar Barge is the ship in which the sun god Ra crossed the sky during the day and the Underworld during the night. The barge was called Atet or Mandjet; the name Mesektet was applied to it only during the night time.

Ramesses II in his chariot during the Battle of Kadesh; relief from the Great Temple of Ramses II, Abu Simbel. Image extracted from Wikimedia Commons (Warren LeMay, 2019).



Scene from the papyrus of Her-Weben (21st Dynasty, Third Intermediate Period; now in Cairo Museum) showing the solar barque of Ra (seated), with the god Seth spearing the monstrous serpent Apep.

Ozymandias' actual Noble Phantasm in FGO is called Ramesseum Tentyris,[7] The Shining Great Temple Complex. Indeed, as we saw above, the Ramesseum was a great temple complex and I suppose it looked very shiny back then. Tentyris is the Greek name of Dendera, a small town in the middle of Egypt.[8] The thing is, the Ramesseum is not located there — it's in Thebes! Besides, the Noble Phantasm's animation shows a pyramid, which is not part of the Ramesseum.[9]

FGO says the height of Ozymandias' reign was when Nefertari gave birth to the second prince. I'm not sure why FGO has chosen that point in time, because that's very early on (again, he had nearly 100 kids) and Ramesses II definitely achieved way more afterwards (even if we discount his blatant royal propaganda). Besides, the statement is just wrong in other accounts. While the first prince (Amun-her-khepeshef) was a son of Nefertari, Isetnofret was the mother of the second prince (which was also named Ramesses). The second son of Nefertari was actually the third prince. His name was Pareherwenemef and we don't know much about him other than that he participated in the famous Battle of Kadesh and that he died before his two older brothers. You can learn more about Egyptian royals in Dodson & Hilton (2010).

FGO goes with the trend of popular literature and cinema in considering Ramesses II to be the Pharaoh mentioned in the Bible's Exodus and, thus, a contemporary (and friend) of Moses (as seen in *Fate/Prototype: Fragments of Sky Silver*). Needless to say, Moses is a mythical figure, not a historical one, and thus, Ramesses II has nothing to do with Moses or with the likewise mythical Exodus (Dever, 2001; Meyers, 2005). In FGO, of course, one does not need to be real to be a Servant, so it's okay for Moses to exist there.

Nefertari

Alright, I know Nefertari is not a playable Servant in FGO, but I think she deserves a section of her own here. After all, she is one of the most famous queens of Egypt (together with Nefertiti from the 18th Dynasty).

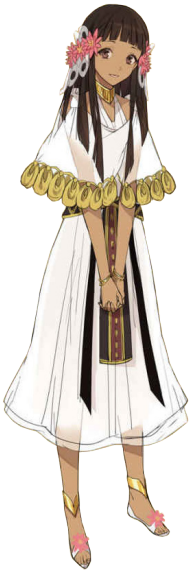
Nefertari was the first of Ramesses II's two Great Royal Wives; as we saw above, the other was Isetnofret. He married both before he ascended to the throne and likely when he was still in his teens. FGO goes with popular knowledge that Nefertari

[7] Misguidingly, this is also the name of Ozymandias' city in FGO's Sixth Singularity. It is neither the actual Tentyris and nor does it make sense to live in your own funerary temple.

[8] Dendera is famous for a temple complex that includes a beautiful Temple of Hathor, the goddess of fun stuff (music, love, sex, etc.).

[9] Another of Ozymandias's Noble Phantasms (not in FGO) is the Abu el-Hol Sphinx. "Abu el-Hol" is a rendition of the modern Arabic name of the Great Sphinx of Giza. That's the large famous sphinx. It has nothing to do with Ramesses II, though. It was in all likelihood built by Pharaoh Khafre from the 4th Dynasty. The Sphinx appears in Ozymandias's Extra Attack animation in FGO.

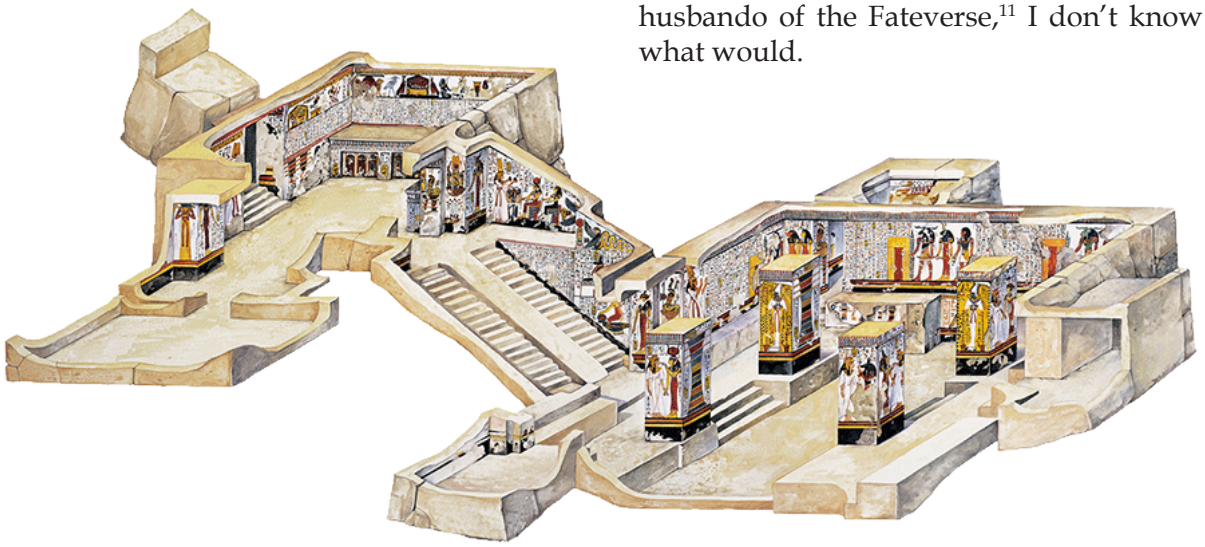
was Ozymandias' true love. She might as well have been according to the surviving evidence we have today (for instance, her amazing tomb in the Valley of the Queens is greater than the tomb of Ramesses himself). However, I should point out that there is comparatively fewer information about Isetnofret to judge her relative importance in this ancient waifu war.



Nefertari. Art by Nakahara.

A painting from Nefertari's tomb in the Valley of the Queens, showing the queen playing senet; public domain.

In any event, Ramesses II sure went to great lengths for Nefertari. He built a magnificent temple for her in Abu Simbel right beside his own temple (see above). In that temple, Nefertari was the personification of the goddess Hathor.[10] There, Ramesses II wrote the following dedication text: "*A temple of great and mighty monuments, for the Great Royal Wife Nefertari Meryetmut, for whose sake the very Sun does shine*" (translation by Kitchen, 1996). If that doesn't make Ozymandias a strong contender for best husbando of the Fateverse,[11] I don't know what would.



Schematics of Nefertari's tomb in the Valley of the Queens; by E. Ferrero, © AUC Press. (It makes a great D&D map, by the way.)

[10] That is appropriate, given that Hathor was the consort of Horus in most accounts. And the Pharaoh, of course, was identified as an incarnation of Horus on Earth. In *Fate*, Ozymandias also likens Nefertari to Hathor.

[11] Of the Nasuverse, actually.

Façade of the Small Temple at Abu Simbel; image extracted and modified from Wikimedia Commons (J. Bon, 2008).

A painting from the tomb of Sennefer (Thebes, 18th Dynasty), showing the deceased with offerings and lotus flowers; image extracted from OsirisNet (www.osirisnet.net).

Nefertari was highly educated and was involved in court and foreign diplomatic matters. So, in all likelihood, she was a more active and integral part of the government than most other queens. References to that have been found in documents from Near East kingdoms. She died in 1,255 BCE, 42 years before her husband.

In the *Fate* franchise, Nefertari appears in flashbacks from her early years, from the times she and Ozymandias spent with the (mythical) Moses (*Fate/Prototype: Fragments of Sky Silver*). She wears a white dress, as expected, and has pinkish lotus flowers adorning her hair (Ozymandias' final ascension artwork also shows him holding one of those flowers). In Ancient Egypt, lotus flowers were symbols of the sun, creation and renewal and they appear in numerous paintings and reliefs, especially in scenes depicting offerings.

There are two main species of lotus in Egypt: *Nymphaea lotus* (white lotus) and *Nymphaea caerulea* (blue lotus). Some flowers of the white lotus can actually be tinged with pink on the "underside" of the petals, but nothing as dramatic as the ones seen in *Fate*. There is a third, reddish/pink lotus (*Nelumbo nucifera*) that was introduced in Egypt from Persia. But that happened during the Late Period, way after the time of Ramesses.

Darius III

Well, this is not an Egyptian character. Rather, he was the last king of the Achaemenid Empire of Persia. However, the Persians had conquered Egypt before Darius III's time, so he was by default the Pharaoh from 336–332 BCE, the last ruler of the "31st Dynasty". The local governors (satraps) who ruled Egypt under Darius III were called Sabaces (died in 333 BCE) and Mazaces. The latter was very quick to surrender the country when Alexander arrived (see below).

In FGO, Darius III belongs to the Berserker class. I won't discuss him further here, because he is not an Egyptian character per se and I have no expertise in Persia. However, I'll venture saying that the Servant definitely doesn't look like the real Darius III did.

Darius III (Stage 3). Art by PFALZ.

Alexander

Alexander and Iskandar (Stage 4 artwork). Art by BUNBUN and Takeuchi Takashi, respectively. One wonders how Iskandar didn't end up being another Saberface.

Okay, not Egyptian again, I know. Alexander III of Macedon, known as Alexander the Great, is famous due to his large military campaign, conquests, and the effect (for good or ill) he had in the subsequent history of the world. As such, I won't extend myself about his life and curriculum, but I have to give some background about the important role he played in Ancient Egypt.

Alexander reached Persian-dominated Egypt in 332 BCE. The satrap Mazaces just handed the country over to Alexander, who was received by the people as a liberator. I assume that by then, the people of Egypt must have been sick and tired of the Persians. Alexander was even proclaimed son of the god Amun[12] by the oracle of Siwa Oasis.

Alexander was the Pharaoh of Egypt from 332 to his death in 323 BCE, though he stayed only a short period in Egypt, of course. While he was there, he founded the city of Alexandria on the Mediterranean coast, following the Hellenistic style.[13] Alexandria later became the capital of Egypt under Ptolemaic rule (and Roman and Byzantine as well). It was also a learning and cultural center during the Ptolemaic era, with the first museum ever built (known as the Musaeum or Mouseion) and its famous library. But what is 'Ptolemaic' anyway?

After Alexander died, his extensive empire was divided between his closest companions. Ptolemy was one of Alexander's most trusted generals. He managed to get control of Egypt, became pharaoh, and started the Ptolemaic Dynasty. Ptolemy I was Macedonian Greek and brought lots of elements of Hellenistic culture to Egypt. Though Ptolemy adhered to the ancient Egyptian model of government and supported local customs and culture to some extent, part of the Egyptian traditions and laws were superseded by Hellenistic ones. Several cultural aspects also became merged and syncretized.

Ptolemy I was succeeded by a number of other Ptolemies. From Ptolemy IV onwards, the kingdom declined, with local rebellions, a good amount of manga-like incest, and Hollywood-like family rivalries, betrayal and murder. If you think *Game of Thrones*

[12] For more on Amun, see my article about *Persona* (Salvador, 2015).

[13] You can find a nice reconstruction of Alexandria in *Assassin's Creed Origins* (Ubisoft, 2017).

had plenty of those, you know nothing — about the Ptolemaic era, that is. You can check the book by Hölbl (2001) to learn more.

Well, enough with that and back to FGO. There are two Servants based on Alexander: the first one is the boy Alexander and the second one is the adult Iskandar (that's the eastern/Persian rendition of the name). Both Servants appropriately belong to the Rider class and at a first glance, have a rather generic anime look. However, the skin color is in line with his Mediterranean origin and there is a sort of popular idea that Alexander had red hair, and FGO's Servants follow suit. The only color depiction of Alexander, however, shows him with dark hair (see Fildes & Fletcher, 2004 for a full dossier on Alexander). The hair style of Iskandar (minus the beard) is actually in line with depictions of the real Alexander, who wears it in a so-called *anastole* style, with a central upsweep. In fact, Iskandar's design could have actually been based on that famous color depiction of Alexander from Pompeii, though he is clearly a buffed-up version of the original.

Alexander the Great. Detail from a mosaic of the House of the Faun, Pompeii, ca. 100 BCE; public domain.

Alexander and Iskandar carry a sword that should be Macedonian in design. The size is about right for a *xiphos* but the design, with its long and narrow hilt (or grip, to be more precise) and the somewhat triangular blade, is a bit off. Young Alexander's Noble Phantasm is Bucephalus, which is just the name of Alexander's horse. Iskandar's regular sprite already shows him mounted on Bucephalus and his Noble Phantasm is called Ionioi Hetairoi, or Ionian Companions. The *hetairoi* (companions) were the elite cavalry of the Macedonian army, though no one is riding horses in the Noble Phantasm animation.

Cleopatra

Cleopatra (Stages 1 and 3). Art by Komatsuzaki Rui.

The last Pharaoh of the Ptolemies was Cleopatra VII, which is the one known simply as Cleopatra to us due to the numerous books, films, etc. All these popular entertainment media have twisted Cleopatra's history and character so much that they became almost free of historical facts. So, let's start with a simple request: please forget all the *femme fatale* nonsense you've seen; that was all spun by old insecure male scholars. Now let's explore actual facts known about the last Pharaoh.[14]

She was born in 69 BCE, daughter of Ptolemy XII and, in all likelihood, an Egyptian priestess. That means Cleopatra was actually part Egyptian, in contrast to the other Ptolemaic rulers. Supposedly, her mother taught Cleopatra about Egyptian culture and that's the reason why the future Pharaoh had so much knowledge of and respect for it — yet another stark contrast to her predecessors. She studied and attended lectures at Alexandria's Musaeum and was

[14] Cleopatra's biographies by Roller (2010) and Fletcher (2008) are good reads if you're interested in learning more.

a published medical authority,[15] having authored a work that we know as *Cosmetics*, preserved only as fragments. Despite the interpretation such name might have today, Cleopatra's work was medical and pharmacological in nature, dealing with remedies and prescriptions, and weights and measures.[16] She could also read and write several languages and was extremely knowledgeable regarding Egyptian, Greek and Roman history.

Cleopatra was originally the second in line to the throne, but by the time her father died, her elder sister Berenike IV had already been executed. Thus, Cleopatra became Pharaoh jointly with her younger brother Ptolemy XIII, as there was opposition towards a woman ruling alone. Soon, a civil war broke between the siblings. Julius Caesar[17] arrived and had a hand in settling the war: Ptolemy XIII died during the conflict and Cleopatra became the sole ruler. As Pharaoh, Cleopatra VII started to stabilize and rebuild Egypt.

She had a son with Caesar, who was named Caesarion. After Caesar's death, she tried to have her son accepted in Rome as his heir, which would make him a very powerful figure. The Romans, however, would have none of it and she failed. She then allied herself with those who would avenge Caesar's death: Octavian (Caesar's grand-nephew) and Antonius (a.k.a. Mark Antony). Antonius worked with Cleopatra to make Egypt a beacon of stability in the Near-East, helping to expand its territories. During that time, Cleopatra and Antonius had twins, and yet another child later on.

After a complete failure in the Parthian War, Antonius deemed he could not return to Rome and went to live with Cleopatra in Alexandria. In Egypt, Cleopatra officially recognized Antonius as her husband, and their children as heirs, which did not sit well with Octavian, then the sole ruler in Rome. Most of the popular tales about Cleopatra regarding her personality and lifestyle sprouted in that period, as Roman propaganda gathered all the empire's prejudices against foreigners and women to target her.

Octavian also saw himself as Caesar's heir and did not recognize Caesarion. All of this led to war and eventually Octavian invaded Egypt. Antonius committed suicide and Octavian captured Cleopatra, who had tried to flee while leaving Caesarion on the throne.[18] With that, the Egyptian Empire finally fell and became a part of Rome. Cleopatra did not want to be paraded as a trophy in Rome and this led her to committing suicide. That is far from being confirmed, though, as she could have as easily been dispatched by Octavian and/or his men. Legends say that she committed suicide through a self-inflicted snakebite, a story that has become solidified in Cleopatra folklore.

Cleopatra's modern Western clothes in FGO (Stages 1 and 2) might be due to her perceived status as a *femme fatale* by the public (and hence, designers). As Levy (2006) has argued, the "Westernesque femme fatale" of Japanese literature (and naturally, we can add pop culture to that) typically has a modern Western appearance and behavior. In a nice twist, FGO recognizes that this vision of Cleopatra is distorted and the game informs the player that Cleopatra's appearance as a Servant is due to the baseless rumors about how "that devilish woman seduced the Roman generals" (Fate/Grand Order Wikia, 2020). Her Stage 3 costume is

[15] Cleopatra VII is also a character in *Assassin's Creed Origins*, so I was planning on writing about her for the next part of my "The scientists of Assassin's Creed" series. See Salvador (2019) for the first part about James Cook and Charles Darwin.

[16] Recipes for soaps and hair dyes are also attributed to Cleopatra.

[17] He's also a Servant in FGO, though I won't talk about him here.

[18] Thus, one could argue that Caesarion was in fact the last Pharaoh, a fact that is even recognized by FGO. However, given that he never actually ruled alone, we can disregard that idea.

a pleated white dress, which is more in line with what we know of Egyptian clothing; even so, she retains the high heels.

Cléopâtre et César (Cleopatra and Caesar), oil on canvas by Jean-Léon Gérôme, 1866 (image extracted from Wikimedia Commons; public domain). This painting is considered a classic example of Egyptomania by experts, but I suppose we can consider it a 19th-century example of Rule 34 by a French painter.

Portrait of Cleopatra on the obverse of a 40 drachms coin (ca. 51–30 BCE, Alexandria); image extracted from Wikimedia Commons (O. Nickl, 2017).

We do not know what Cleopatra looked like, as the only remaining "portraits" are those found in coinage. We only know a few things: that she was rather short; had a prominent nose (supposedly a family trait); and that the quote that she was unattractive is actually false, a misquote from Plutarch's original.

Cleopatra's sprite includes a large golden cobra. That could be a reference to the suicide of the legends, but it could also just be a reasonable usage of one of the most powerful and pervasive symbols of protection of Ancient Egypt, especially related to pharaohs. A rearing cobra can be found on the nemes headdress of the king; it is called *uraeus* (see the photo of the golden mask of Tutankhamun's mummy above and the discussion on her Noble Phantasm below). The cobra was also typically related to Wadjet, the tutelary goddess of Lower Egypt, but it could also be used to represent other goddesses, such as Neith and Meretseger.

Cleopatra (Stage 3 sprite).

Her Noble Phantasm is called "Uraeus Astrape" and includes a giant fiery cobra and a direct mention to the uraeus. Astrape is the goddess (or rather, the personification) of lightning in Ancient Greece, so I have no idea why that's part of the name of Cleopatra's Noble Phantasm, especially because it's not a lightning-themed special attack.

Cleopatra belongs to the Assassin class in FGO, a choice that might be related to the *femme fatale* thing mentioned above. Cleopatra herself mentions in FGO that she doesn't

know why she's an Assassin, given she never killed anyone. For what we know, she could have been a Rider, as she was skilled in horseback riding and hunting, as all royals were, and also a great naval commander. Or she could be a Ruler, given that she was a remarkable one. As Roller (2010: 2) puts it: "descended from at least two companions of Alexander the Great, she had more stature than the Romans whom she opposed." As Egypt's ruler, Cleopatra worked hard to salvage a dying kingdom (which was in a precarious state due to the incompetence of her predecessors) and to stand up to Rome — and she nearly succeeded. She was almost a messianic figure in the eastern Mediterranean, who represented the possibility of a future without Roman domination. Just imagine how different the world could have been if a female Pharaoh had defeated Rome in its early days.

The Egyptian cobra, *Naja haje*; image extracted from iNaturalist (observation #32149684, by Alex Ville, 2019).

FINAL THOUGHTS

Overall, FGO's Egypt-inspired characters are actually reasonable representations, even though they draw a lot from the "lore" of Egyptomanias past. I suppose it's understandable that historians and other scholars dislike the fact that King Arthur and Miyamoto Musashi were transformed into waifus.[19] But I think that the *Fate* franchise — and FGO in particular, given its proportions — can actually help to increase interest in topics that are otherwise mostly academic. Many players will want to know more about their favorite characters and will inevitably end up reading about those historical, mythological and literary figures. If that's not a good way to make people interested in History, Archaeology, Mythology and/or Literature, then I don't know what is.

And now I'm gonna go on a limb here and imagine you, my dear reader, will want to learn more about Ancient Egypt. You've made it this far, after all, which is a good sign. In that case, the book by Silverman (2003) is a very accessible and thorough introduction. If you fall in love with Ancient Egypt like I did and the time comes when you want more hardcore academic books, Shaw (2004) and Kemp (2007) will be good starting points.

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[19] Not to mention the global academic and legal discussions about the evils of the gacha mechanic of FGO and so many other games (see for instance, Hood, 2017; Wiltshire, 2017; Drummond & Sauer, 2018).

I learned something today! Image extracted and cropped from Learning with Manga!, Episode 25 (© TYPE-MOON / FGO PROJECT; https://fate-go.us/manga_fgo2/).

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Figure credits

The images of *Fate* characters used herein were extracted from Fate/Grand Order Wiki, with the exception of Nefertari, extracted from TYPE-MOON Wiki; ©Aniplex.

About the author

Dr. **Rodrigo Salvador** is a zoologist and paleontologist who studies snails; or a malacologist, if you will. Nevertheless, he has dabbled quite a bit in Egyptology and often writes about geek culture topics featuring Ancient Egyptian stuff. Ozymandias and Cleopatra are on his top 5 Servants list, though the gacha gods haven't allowed him to summon them yet. Rate up is a lie!

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Cultural lepidopterology in modern Japan: butterflies as spiritual insects in the Akihabara Culture

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Butterflies are one of the most popular insects because they have diversified and colorful wings. They were probably the first insects to be collected purely for their beauty (Preston-Mafham, 2004). In the Western culture, Dicke (2004) showed that butterflies and moths are the most frequently depicted insects in Western art from 13th century till date. Hvenegaad (2016) recognized 81 insect festivals in North America through a web-based research study in 2015. Of these festivals, 49% focus on all insects. In festivals that target one group of insects, 31% focus on butterflies, followed by 4% on dragonflies and honeybees, and 3% on caterpillars and blackflies. Furthermore, Shipley & Bixler (2017) demonstrated that modern American people are generally friendly towards butterflies as revealed in an interview with 60 participants, in the age range of 18 to 50 years.

Similarly, Korean people are likely to show favorability towards butterflies in general (Hoshina, 2019). In Hampyeong of the southwestern Korean peninsula, a butterfly festival has been held every year since 1999. The festival is one of ecotourism, during which visitors observe many butterflies and flowers, learning about the natural environment and eco-friendly agriculture (Kim et al., 2008a, 2008b). Additionally, the 3D Korean animation *Larva* (TUBAn Co., 2006), in which main characters are caterpillars, is very popular and has been broadcasted in Japan since 2013. Moreover, the logo of a Korean airplane company, Jin Air, is a butterfly (there are no butterfly logos for Japanese airplane companies). Moreover, many butterfly-shaped accessories are sold in Seoul City (Hoshina, 2019).

What did older Japanese people traditionally think about butterflies? Dunn (2000) indicated that famous Japanese poets in the *Edo* period (1603–1868) wrote their works, *haiku*, using butterflies, dragonflies, cicadas, crickets, grasshoppers, and fireflies as their subject matter. However, Japanese people loved fireflies and singing Orthoptera[1] more than butterflies before World War II (Hoshina, 2017a, 2018b), likely due to their limited seasonal appearance. They deeply love cherry blossoms and prodigiously drink liquor around the roots of trees every spring because flowers open for only about ten days in April. On the contrary, most erstwhile Japanese people felt that butterflies, especially the common species *Paplio xuthus* Linnaeus, 1767 (the Asian swallowtail) and *Pieris rapae* (Linnaeus, 1758) (the small cabbage white), were tedious, yet beautiful, because they are multivoltine,[2] and adults emerge from spring to autumn (Hoshina, 2018a).

Moreover, although butterflies often appear in many worldwide mythologies (for

[1] Orthoptera is the order of insects that includes grasshoppers, locusts, and crickets.

[2] A multivoltine species has two or more broods of offspring per year.

example, Wyman & Bailey, 1964; Shinoda, 2018), they are not described in the Japanese myths (Hoshina, 2017b). In addition, in the oldest Japanese poetical work, *Man'yōshū* (万葉集), which was edited in the 8th century, there are no poems of butterflies (Takahashi, 1988). Furthermore, older Japanese people were uncomfortable with the extreme changes of butterflies from larvae to adults (Kozai, 2012). Thus, they generally paid little attention to butterflies before World War II.

So, what do present-day Japanese people think about butterflies? This will be discussed here, related to cultural entomology. Recently, some papers about Japanese video games included in 'Akihabara Culture' were published in a branch of cultural entomology (Kawahara, 2007; Hoshina, 2018c; Kittel, 2018; Schmidt-Jefferus & Nelson, 2018; Shelomi, 2019). Further, Kritsky & Smith (2018) in "Akihabara Culture: Toys, Video Games, and Anime from Modern Japan" provided a descriptive introduction of cultural entomology. Generally, foreign researchers thought that Japanese people traditionally have a favorable disposition towards insects (Hogue, 1987; Dunn, 2000). Therefore, some cultural entomologists may be interested in how the insects are depicted in Akihabara Culture, which is a symbol of the modern Japanese culture. I have previously discussed rhinoceros beetles and fireflies appearing in Akihabara Culture (Hoshina & Takada, 2012; Hoshina, 2018c). Therefore, I have focused the discussion on butterflies in this paper.

BUTTERFLIES AS SOULS

In the ending of a Japanese TV animation, *This Ugly yet Beautiful World* (この醜くも美しい世界, romanized as *Kono Minikuku mo Utsukushii Sekai*; by Gainax), in 2004, a scene of numerous red butterflies was shown, representing souls of all lives before birth, flying into the universe from Earth.

In a Japanese animation movie, *A Silent Voice* (映画 聲の形, *Eiga Koe no Katachi*; by Kyoto Animation), in 2016, the soul of the heroin's grandmother transformed into a white butterfly after her death and flew to the heroin in order to see her again in the funeral ceremony (Miyanoshita, 2019).

Cafe Stella to Shinigami no Chou (喫茶ステラと死神の蝶, *Kissa Stera to Shinigami no Chou*; by Yuzusoft) went on sale in 2019,

Figure 1. Aoi Sorakado and a butterfly; © Visual Arts/Key.

which is a romantic fantasy graphic novel. One of the main characters, Kōsei Takamine, is run over by a car and dies soon after the start of the story. However, he can turn back the clock to before the traffic accident through a strange power of a blue butterfly. Subsequently, a deceased female appears before him and explains that blue butterflies are human souls and dangerous for the world. Therefore, he decides to support her in collecting butterflies.

Summer Pockets is a popular romantic graphic novel released in 2018 (by studio Key). The novel is set in a small rural island. The hero, a boy named Hairi Takahara, comes to the island from a large city during a summer vacation and meets a shrine maiden girl, Ao Sorakado. On the island, shining whitish strange butterflies fly about a mountain at night. These butterflies represent incarnations of the memories of people who died with regret. She searched for butterflies having memories of her older twin sister, Ai, who is in a death-like state (Fig. 1). Hairi begins to look for butterflies with her.

BUTTERFLIES AS SPIRITUAL MEDIUMS FOR WOMEN TO RELEASE MAGICAL POWERS

A series of action games, *Samurai Warriors* (戦国無双, *Sengoku Musō*; by Koei), is set during the Japanese Civil War in the 16th century, and its first product went on sale in 2004. Players operate military commanders, or their wives or sisters, aiming to defeat the opposing army. One of the popular characters, Nōhime, is a voluptuous and mysterious lady who is called "a butterfly accompanying her husband, like Satan". She usually fights by using long claws and sometimes releases many purplish-red butterflies to initiate explosions that kill many enemy soldiers (Fig. 2).

Hisahide Matsunaga is a character in the animation *The Ambition of Oda Nobuna* (織田信奈の野望, *Oda Nobuna no Yabō*; by Studio Gokumi and Madhouse), which was broadcasted in 2012 and set in the Japanese Civil War period in the 16th century. She is half-Japanese, a witch, and a lush and mysterious girl. She can suddenly teleport from a faraway place, accompanied by many golden-yellow butterflies, to confuse her enemies.

Figure 2. Nōhime in Samurai Warriors 4-II; ©Koei Tecmo Games.

Figure 3. Yukina Shinjō in *Manatsu no Yoru no Yuki Monogatari*; © Ex-One.

A graphic novel, *Manatsu no Yoru no Yuki Monogatari* (真夏の夜の雪物語; by Ex-One), went on sale in 2011 and is a romantic fantasy graphic novel. The heroine, Yukina Shinjō, is a *yuki-onna*, which means a beautiful snow fairy filled with much love, a famous Japanese traditional monster wearing a kimono. She releases many frozen pale butterflies that freezes the whole town in the end of the story (Fig. 3).

In this way, butterflies often become spiritual mediums in order to charge magical powers released by female characters in the Akihabara Culture.

BUTTERFLY FLIGHT IN THE DREAM WORLD AND CONNECTION TO THE REAL WORLD

In the Blackfoot tribe of North America, there is a myth in which butterflies are spreaders of sleep and dreams (Cherry, 2005; Prischmann et al., 2009). In the Akihabara Culture, butterflies are often given a similar role. A graphic novel, *Natsu Yume Nagisa* (ナツユメナギサ, by SAGA PLANETS), went on sale in 2009 and is an emotional romantic graphic novel. Its story is set on the Eternal Summer Island existing in a dream of the heroine, Ayumu Nanase. Many blue butterflies fly laughing in a low voice all over the island. These butterflies are souls that invite humans into her dream. In the end, she sees her deceased lover in her dream, and a cloud of butterflies disappears entering into her body (Fig. 4).

The TV animation series *Sister Princess*, by Zexcs Inc., was broadcasted in 2001. The main characters included one elder brother and twelve younger sisters that loved him very much. One day, one of the sisters, Aria, lost a ribbon, which was a present from her brother, and wept over it. She saw a tree sprit changing into an elderly gentleman and looked for the ribbon with him. Just then, a green butterfly appeared before them and took them to a dream world. Once they found her ribbon, they returned to the real world.

Akai Ito (アカイイト, by Success Corporation) is a horror graphic novel that went on sale in 2004. The heroine, Kei Hatō, is an ordinary high school student. However, she is targeted by an *oni*, a traditional Japanese devil, because her blood is a favorite dish for *oni*. Her cousin, Yumei Hatō, became a disembodied soul ten years ago,

Figure 4. Ayumu Nanase in *Natsu Yume Nagisa*; © SAGA PLANETS.

gained overwhelming magical powers, and has been guarding Kei from oni until the present. Yumei appears as many pale butterflies in Kei's dream to inform her of the approaching dangers.

Hapymaher (ハピメア, *Hapimea*; by Purple Software) is a strange graphic novel that went on sale in 2013. The main character, Tōru Naitō, always suffers from a nightmare. One day, he meets a mysterious girl, Arisu Toriumi, in his dream. She can appear in the dreams of various people. A strange love story between Tōru and Arisu begins. Her ornament is blue butterfly-shaped (Fig. 5), and a bluish butterfly slowly flies around in the opening movie of the game. The butterfly is a representation of the strange dream world.

Figure 5. Arisu Toriumi in *Hapymaher*; © Purple Software.

BUTTERFLIES TRANSPORT HUMANS TO DEATH LANDS

Saint Seiya (聖闘士星矢, also known as *Knights of the Zodiac* in some places) was a popular Japanese comic book in the 1980s and had a Greek mythology motif. In its story, a butterfly called *fairy* was sent by a god of the underworld, Hades, to keep watch over holy soldiers under the goddess Athena. However, a villainous soldier, Papillon, under Hades, released many butterflies and tried to force Athena's soldiers into the underworld with these butterflies.

Fatal Frame II: Crimson Butterfly (零. 紅い蝶, *Zero: Akai Chou*; by Tecmo), released in 2003, is a horror video game where the main characters are the sisters Mayu and Mio Amakura. They see a few red butterflies in the dark forest and are directed to an accursed village by those butterflies, in which a series of murders occurs and many evil spirits ramble about (Fig. 6). Players control the sisters and aim at escaping safely from the village.

Tasogare no Folclore (黄昏のフォルクローレ; by Citrus), released in 2019, is a bizarre graphic novel set during the Japanese modern monarchical period (1868–1945). The heroine, Supika Otobe, is a beautiful girl from a very rich family; however, she seldom takes a meal and mainly absorbs men's energy for her survival. Most men die soon after they are deprived of energy by her. In the opening movie of the game, a blue and gaudy butterfly weirdly flies around, while sometimes getting caught in a cobweb. The butterfly is a representation of Supika who drives men to death.

WEIRD BUTTERFLIES FLYING IN THE DARKNESS

Butterflies fly about, sometimes forming a large group, in the dark magical world of Japanese animations and video games, although most butterflies usually fly in the daytime and do not form large groups in the real world. *Oni Uta* (鬼が来たりて、甘えさ

Figure 6. The Amakura sisters in *Fatal Frame II: Crimson Butterfly*; © Tecmo.

せろとのたもうた, *Oni ga Kitarite, Amaesasero to Notamouta*; by 130 cm) went on sale in 2003 and is a strange romantic graphic novel. The main character, Akito Mimasaka, is the heir of a shrine, who is stabbed and killed by a thief soon after the start of the story. However, an *oni* princess, a traditional Japanese devil, which is enshrined at the shrine, gives him magic powers, and he is revived as a half-man and half-*oni*. In the opening movie of the novel, a red butterfly representing Akito's blood slowly flies in the shrine at night.

Boku no Te no Naka no Rakuen (ボクの手の中の楽園; by Caramel-Box) went on sale in 2009 and is a fantasy romantic graphic novel set on an island based on medieval Europe. The story begins when the hero, Yū, loses his memory and is cast ashore on the island. On the island, there is a piece of folklore saying that butterflies can travel between different worlds and bring mad persons from the mountains into town. One day, chimerical mad people appear in a town on the island and commit murders. Yū decides to solve the cases, accompanied by a group of female warriors. In the opening movie of the novel, a cloud of pale butterflies flies around the dark blue skies.

Nights of Azure (よるのないくに, *Yoru no Nai Kuni*; by Koei Tecmo) went on sale in 2015 and is a horror action role-playing game set in early modern Europe. In its world, many monsters dominate cities at night. The heroine, Arnice (アーナス), is a holy knight, who leaves for a battlefield filled with monsters on an order from the holy Pope. In the opening movie of the game, a cloud of blue butterflies flies in the darkness (Fig. 7).

The roles of butterflies in the three cases above were to emphasize the weird atmosphere in each fictional world. In fact, the director of *Boku no Te no Naka no Rakuen* commented that he used butterflies to generate a negative feeling and a dramatic impact in the game (Jive Editorial Department, 2009).

DISCUSSION

In the animations and video games belonging to the Akihabara Culture, there are often scenes in which few butterflies fly slowly around flower gardens during daytime. These butterflies represent a mild day in spring. Moreover, butterfly-shaped monsters sometimes appear in a variety of video games, including role-playing games, such as *Pokémon*, and entries in the series *Dragon Quest* and *Disgaea* (Hoshina, 2013;

Figure 7. *Nights of Azure*; © Koei Tecmo.

Kittel, 2018; Schmidt-Jefferus & Nelson, 2018). However, butterflies described in this paper have another point-of-view from the butterfly-shaped monsters in cultural entomology. In role-playing games, butterfly-shaped monsters are only one group of all insect-like monsters and do not have special roles in the whole stories and views of the world in each fictional work. By contrast, butterflies described in this paper are thought to be particularly meaningful with respect to cultural entomology, because they act on characters, stories, and atmospheres of fictional works.

As mentioned above, after all, butterflies are described in this paper as spiritual insects. Of all insects appearing in the Akihabara Culture, only butterflies and fireflies can play these roles (Hoshina, 2018a, 2018c). There is a tendency to consider butterflies as spiritual insects in both the Akihabara Culture and around the world (Cherry, 2011). For example, in Greek culture, the soul at corporeal death is thought to leave the body in the form of a butterfly (Adachi, 1995; MacRae, 2007). The Greek coddess Psyche, who represents the soul, has been illustrated with butterfly's wings (Tüzün, 2015). In Transylvania, it is thought that many people can project their souls as a butterfly (Murgoci, 1998). In Europe, butterflies have maintained their status as the iconic representations of the soul since medieval times (Dicke, 2000; Nazari, 2014). The Māori in New Zealand believe that the soul returns to earth after death as a butterfly. In the sacrificial moment at the symbolic center of the Aztec culture, the freed soul/butterfly was said to be released from the body by an obsidian blade and simultaneously captured within the stone (MacRae, 2007). In some Chinese folktales, it has been said that the soul of the dead becomes a butterfly and returns to their lover (Segawa, 2016). According to another report, ancient Egyptians believed that butterflies possessed a symbolic or magical meaning related to the afterlife, although there are various hypotheses concerning the symbolic significance of butterflies (Nazari & Evans, 2015). Thus, butterflies have been used to represent the souls of the deceased individuals worldwide.

In addition, Europe has bizarre regional folklore combining butterflies and vampires; in Romania, a type of vampire, *nosferat,* can transform into a butterfly, black cat, black dog, and a straw, while in that of the Mari people in Volga Basin, the *buber* vampire transforms itself into a butterfly and escapes from its own mouth if its body is set on fire (Hiraga, 2000). In Japan, there is no folklore combining butterflies and vampires. However, a famous Japanese cartoonist, Narumi Kakinouchi, depicted butterflies sucking blood from a female vampire in her 2002 work *Vampire Yui Kanonshou* (吸血姫夕維 香音抄).

In Japan, there are some traditions in which butterflies are also regarded as souls of deceased individuals (Imai, 1978). For example, after Christianity was introduced to Japan in the 16th century, unique interpretations were sometimes added to its doctrine. In a tradition in Nagasaki Prefecture, where Christianity is strongly followed, the Holy Spirit was thought to change into a butterfly, flying into the Blessed Mary's mouth, for which Mary conceived Christ (Usui, 1982). According to another report, it is likely that the ancient Japanese witnessed butterflies gathering around corpses for sapping, thus regarding this as the incarnation of the dead (Imai, 1978).

Furthermore, butterflies have been said to be insects indicating an ominous sign in ancient Japan. According to an official history book, *Azuma Kagami* (吾妻鏡), which was edited by the government in the 14th century, many yellow butterflies gathered in the capital city, Kamakura, inciting fear in the masses of the inauspicious sight in 1247. In fact, the powerful Miura family raised a rebellion against the government soon after the incident. In addition, during the *Edo* period, the pupa of *Byasa alcinous* (Klug, 1836) (the Chinese windmill) was called *okiku-mushi*, a name derived from a woman put to death, Miss Okiku, and became a model of a monster appearing in a famous Japanese ballad drama, *Banshū Sarayashiki* (播州皿屋敷). People feared the pupa of *B. alcinous* due to similarities in its appearance with that of a woman tied up

with her hands behind her back (Fig. 8). As such, *B. alcinous* is still regarded as a weird insect. For example, in the opening of a modern Japanese horror TV animation, *Jigoku Shōjo* (地獄少女, also known as *Hell Girl;* by Studio Deen), in 2005, an adult of *B. alcinous* was luridly flying. Apart from that, there is a strange tradition in Japan that butterflies eat human flesh (Imai, 1978).

As mentioned in the introduction above, older Japanese individuals prefer fireflies and singing Orthoptera, rather than butterflies. In contrast, at present, many Japanese people recognize the beauty of butterflies, and many amateurs enthusiastically collect butterfly specimens. There are two societies, The Butterfly Society of Japan and The Butterfly Science Society of Japan, studying only butterflies, separate from The Lepidopterological Society of Japan, although in most cases only one society for Lepidoptera has been established in any given country.

However, many roles of butterflies are negative, such as the representation as the souls of the dead and weirdness in the Akihabara Culture. There is a Japanese proverb, "Beautiful roses have thorns," meaning that extremely beautiful things are dangerous. Butterflies are not only the embodiment of beauty but are also still viewed as mysterious and sinister insects for many Japanese people. Thus, the Akihabara Culture has inherited the traditional views of butterflies.

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Figure 8. Pupa of *Byasa alcinous.* © Ishikawa Insect Museum.

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