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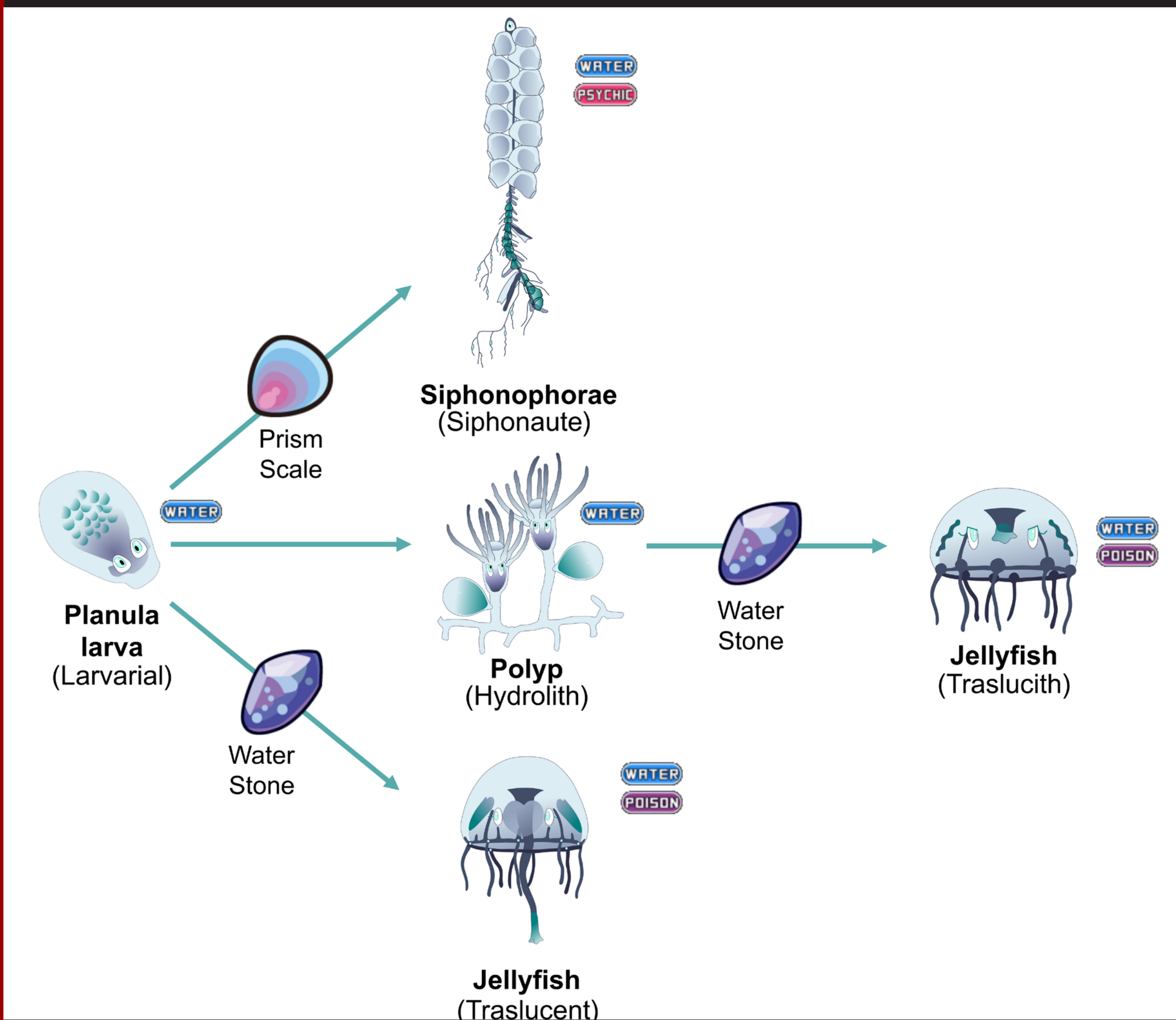

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Cover art: Fakemon designs based on cnidarians (artwork by C. Odette Carral-Murrieta1, Mariae C. Estrada-González).

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Togemon: a Cactaceae in the *Digimon* world

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Digimon is one of the most well-known Japanese animated series of the past decades. 'Digimon' is an abbreviation of 'digital monsters' and the character types in the Digimon world are based on various living things, such as animals and plants, but also mythical and alien-like creatures (Digimon Web, 2023; Wikimon, 2023).

One of the plant-type monsters in *Digimon* is Togemon, which in the first animated series (1999) belonged to the character Mimi Tachikawa (DigimonWiki, 2023a). Togemon is a champion level form of Palmon. From its body and features, Togemon resembles a plant of the Cactaceae family, particularly a species of cactus. This article discusses Togemon's morphological features in botanical terms, considering it a Cactaceae plant.

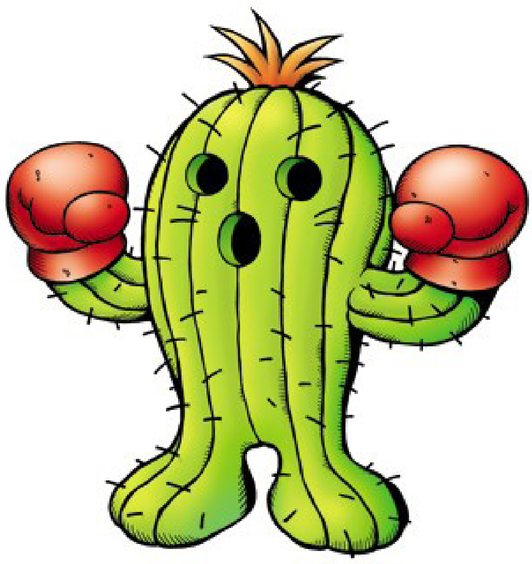

Figure 1. Togemon, official artwork (source: DigimonWeb).

CACTACEAE

The species of family Cactaceae – i.e., the cacti – live in and are well adapted to arid and semi-arid environments (Pérez-Molphe-Balch et al., 2015), being immediately recognizable because most species have spines. In Cactaceae, "regular" leaves are reduced or absent and some leaves are modified into spines, which arise from specialized tissues of the plant (areoles, located in the axillary meristems) located in the stem or cladode (Simpson, 2010). The term 'cladode' refers to a single node or internode of the stem that is modified to function as a leaf, that is, it becomes responsible for the photosynthesis (Beentje, 2016). The succulent stem of the cactus also acts as a water reservoir for the plant (Binns, 2022).

Cactaceae are distributed mostly in the desertic regions of the "New World" (Simpson, 2010), but can be found all over the world. They have economic importance for society too, as some of the fruits are edible and many species are cultivated as ornamental plants (Simpson, 2010; Pérez-Molphe-Balch et al., 2015; Prisa, 2022). However, they face some threats like habitat loss and degradation, and illegal collection (Ortega-Baes, 2010).

TOGEMON

Togemon (トゲモン) is a champion level plant or vegetation *Digimon*. Its prior form is Palmon, while its next form of evolution is Lilymon, which resembles a lily flower

Figure 2. Togemon uses its special attack Needle Spray against its opponent (source: *Digimon Adventures*).

(*Lilium* spp.). Other forms are Togemon X and Ponchomon. Togemon X looks like Togemon but wears a poncho (a Mexican-style dress) and a sombrero, and carries the so-called X-Antibody (DigimonWiki, 2023b). Ponchomon is a ghost-type Digimon which is rumored to appear when a Togemon has died due to unforeseen circumstances (DigimonWiki, 2023c). Ponchomon looks like Togemon X but has no feet (it is a flying ghost) and still wears the poncho (hence its name) and sombrero.

Togemon's debut was in *Digimon Adventure* animated series episode 6 (aired 11/Apr/1999; Toei Animation) during a battle against Monzaemon in Toy Town, in which Palmon's anger and determination to protect Mimi makes it Digivolve into Togemon.

Togemon was inspired by real cacti, as seen by its body shape and features (Fig. 1). Like a cactus stores water in its stem, Togemon stores its own nutrition in form of data for surviving in barren desert areas (Digimon Web, 2023; Grindosaur, 2023). According to DigimonWiki (2023), the etymology of Togemon is derived from the Japanese word 'toge' (棘), which means 'thorn'. Togemon's signature special attack is 'Needle Spray', in which it spins around and shoots a numerous spine out of its body towards the opponent (Fig. 2; DigimonWiki, 2023). Real cacti do not shoot their spines, obviously. In another one of its usual attacks, called 'Coconut Punch', Togemon uses its fists to rain hits on its opponent like falling coconuts.

REAL-LIFE TOGEMON CACTUS

The species of Cactaceae that served as the inspiration for Togemon is the horse crippler cactus, aka devil's pincushion or by its scientific name *Echinocactus texensis* (DigimonWiki, 2023a). *Echinocactus texensis* is a succulent subshrub species endemic to Northern Mexico and central-southern United States (New Mexico, Oklahoma, Texas) (POWO, 2023).

Figure 3. *Echinocactus texensis* Hopff., showing the tuft-like spines and the reddish fruits (source: Wikimedia Commons; photo by S. Shebs, 2005).

The color of Togemon's body is green, as expected from the cladodes of the stem of Cactaceae, and it bears spines as a modified leaf. In Cactaceae, the cladode or stem takes over the "traditional" function of the leaves in performing photosynthesis or carbon fixation (Huber et al., 2018). Since the stem does the photosynthesis, the leaves are modified into spines which functionally act as protection against herbivores (Aliscioni et al., 2021), while also preventing water loss by evaporation due to its minimal surface area (Kim et al., 2017). Togemon's "tuft of hair" resembles the dried-out flower tepals of *E. texensis*, while his red "boxing gloves" are reminiscent of the reddish fruits of *E. texensis* (Fig. 3).

BOX 1. Description of *Echinocactus texensis*.

Echinocactus texensis (Fig. 3) is generally a solitary plant, pale grayish green to yellowish green in color, about 10 to 20 cm wide (rarely up to 30 cm) and 30 cm tall at maturity and becomes more cylindrical with time (Baker, 2022). The central spines are usually three in number, all recurved or with one erect and straight spine, pale tan to gray in color but often spotted pink or red; the radial spines are typically 4 or 5 in number (Baker, 2022). The flower (Fig. 4) is up to 6 cm long and 6 cm wide, with its inner tepals being bright pink and the stigma lobes being white to pale pink (Baker, 2022). According to Powel & Weedin (2004), the flowering period is in between April and July. The fruits are spheric to ovoid and glossy, with the seeds being irregularly spheric to egg-shaped (Baker, 2022). The bright red fruit is edible (Tropical Britain, 2023).

Figure 4. Flower of *E. texensis* (source: Wikimedia Commons; photo by M. Wolf, 2012).

Togemon is a plant or vegetation type Digimon inspired by a real species of Cactaceae named *Echinocactus texensis*. Overall, the morphological features of Togemon are, as far as possible for a monster, actually quite accurate in relation to the real plant.

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Malacological representativeness in eco-horror movies

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Humanity has always found ways to manifest and remember its culture and history. Films, as audiovisual productions, are an important tool for dealing with complex issues, critically portraying reality, and allowing reflection on social, political, economic, and environmental issues. In addition, when linked to scientific education, they play an important role in expanding the worldview of society (Arroio, 2010).

Film productions of the horror genre illustrate the fears and anxieties that plague a particular generation at some specific moment in history, metaphorically and allegorically establishing a relationship between the real and fictional world (Marchi, 2010).

During the Cold War period (1947–1991), several films starring giant monsters represented the atomic threat (a.k.a. *Godzilla*, 1954; Fig. 1), while at the end of the 1970s, with the growth of the environmental movement, the approach took on another focus and reflected man's concern about its impacts on the environment, represented by films in which animals and plants take revenge on the human race for the abuses against the planet (a.k.a. *The Day of the Triffids*, 1962; Fig. 1), establishing the eco-horror subgenre (Chagas & Almeida, 2015).

Figure 1. Left: poster of *Godzilla* (1954). Right: poster of *The Day of the Triffids* (1962). Source: IMDb.

METHODOLOGY

To verify the malacological taxonomic representativeness (that is, mollusks) in eco-horror films, a survey was carried out in five cinematographic database sites: Internet Movie Database (IMDb); Movie Monster Fandom; The Movie Database (TMDb); The TV Database (The TVDB); and Rotten Tomatoes. The following keywords were used for the search: Octopus; Tentacles; Squid; Molluscum; Mollusk; Slug; Snail; Oyster; Clam; Mussel; and Shellfish. Words were searched for both in English and Portuguese.

Movies from horror, thriller, and science fiction categories were selected, which contained some of the keywords chosen in their titles, and/or in which mollusks were graphically present in their publicity poster, and/or, still, in which the synopsis of the film demonstrates the participation of a mollusk in the plot. The searches were closed when the results started to be repeated in the consulted databases.

The films found were organized in a spreadsheet containing the following indexed information: Original title of the work, year of release, country of origin, genre, director(s) and the represented mollusks in the movie.

RESULTS

Thirty films were found that fit the eco-horror genre in which mollusks were present (Table 1). Cephalopods were the most represented mollusks in 90% of the analyzed films (Fig. 2).

Figure 2. Posters of movies released in the 50s, and 70s starring cephalopods. Left: *Monster from the Ocean Floor* (1954). Center: *It Came from Beneath the Sea* (1955). Right: *Tentacles* (1977). Source: IMDb.

Table 1. Relation of movies found, sorted by release date.

Title	Year	Country	Genre	Director(s)	Represented animal
Monster from the Ocean Floor	1945	USA	Sci-fi	Wyott Ordung	Octopus
20,000 Leagues Under the Sea	1945	USA	Sci-fi/Adventure	Richard Fleischer	Squid
It Came from Beneath the Sea	1955	USA	Horror/Sci-fi	Robert Gordon	Octopus
The Monster That Challenged the World	1957	USA	Sci-fi	Arnold Laven	Gastropod
Kingu Kongu Tai Gojira	1962	Japan/USA	Sci-fi/Action	Ishiro Honda	Octopus
ManClam - The Shell Form Hell!	1962	Canada	Horror	Huw Evans	Bivalve
Gezora, Ganime, Kameba: Kessen! Nankai no Dakaiju	1970	Japan	Horror/Sci-fi	Ishiro Honda	Cuttlefish

Table 1 (cont.)

Title	Year	Country	Genre	Director(s)	Represented animal
Octaman	1971	Mexico/ USA	Horror	Harry Essex	Octopus
Tentacoli/Tentacles	1977	Italy/USA	Horror	Olvidio G. Assonitis	Octopus
Slugs: The Movie/Slug, Muerte Viscosa	1982	USA/Spain	Horror	Juan Piquer Simón	Slug
Shark Rosso Nell'oceano	1984	Italy/ France	Horror/Sci-fi	Lamberto Bava	Hybrid octopus
Deep Rising	1998	USA	Horror/Sci-fi	Stephen Sommers	Octopus
Octopus	2000	USA	Horror	John Eyres	Octopus
Octopus 2: River of Fear	2001	USA	Horror	Yossi Wein	Octopus
The Thing Below	2004	USA	Horror	Jim Wynorski	Octopus
Kraken: Tentacles of the Deep	2006	USA	Comedy/Horror	Tibor Takács	Octopus
Eye of the Beast	2007	Canada	Horror	Gary Yates	Octopus
Monster	2008	Japan	Sci-fi	Eric Fosberg	Octopus
Mega Shark Versus Giant Octopus	2009	USA/England	Horror/Sci-fi	Jack Perez	Octopus
Sharktopus	2010	USA	Horror/Sci-fi	Mike MacLean	Hybrid octopus
Grabbers	2012	Ireland/ England	Comedy/Horror	Jon Wright	Creatures with tentacles
Squid Man	2013	UK	Comedy/Sci-fi	Charlie Cline	Squid
Bermuda Tentacles	2014	USA	Horror/Sci-fi	Nick Lyon	Octopus
Sharktopus vs. Pteracuda	2014	USA	Horror/Sci-fi	Kevin O'Neill	Hybrid octopus
Spring	2014	USA	Horror/Drama/ Romance	Justin Benson	Hybrid octopus
Sharktopus vs. Whalewolf	2015	USA	Horror/Sci-fi	Kevin O'Neill	Hybrid octopus
Night of Tentacles	2016	USA	Horror	Dustin Mills	Octopus
Attack of the Cyber Octopuses	2017	Estonia	Sci-fi	Nicola Piovesan	Octopus
Godzilla: King of The Monsters	2019	USA	Action/Sci-fi	Michael Dougherty	Hybrid octopus
Dà zhangyú (Big octopus)	2020	China	Sci-fi	Frank Xiang	Octopus

Among the countries with highlights in releases, the United States produced more than half of the films found, followed by Japan. In the early decades, films were released briefly and most animals showed gigantism.

The vast majority of analyzed films were released from the 2000s and 2010s onwards, still using mainly gigantism narratives, but now with the plot linked to the impact of human actions on the environment.

Bivalves and gastropods had a punctual presence in the observations, represented in only 3.4% and 6.6% of the films, respectively (Fig. 3), while for the remaining groups of Mollusca, there is no production available.

Figure 3. Posters of movies with the least represented mollusks in eco-horror movies. Left: *Slugs* (1988); source: IMDb. Right: *ManClam! The Shell from Hell* (1962); source: Behance.

DISCUSSION

Regarding the most producing countries, the leadership of the USA, followed by Japan, may be associated with the historical context of the Cold War and the fear of the advancement of science linked to the war industry. The greater production of films from the 2000s is related to the growing concern with environmental issues resulting from the relationship between humanity, the environment and its organisms, in addition to also being related to the advancement of computer graphics technologies, which made it possible to explore new audiovisual resources in the film industry.

Most selected films have direct representations or refer to organisms of the Cephalopoda class. The predilection for these animals may be linked to greater knowledge accumulated about the group by society, in addition to their presence in different types of cultural manifestations, such as food, literature, music, and their presence in cinema. This represents yet another reflection of the fascination that these animals exert on us, whether when linked to intelligent, dark, or dangerous beings, such as the species *Vampyroteuthis infernalis*, *Dosidicus gigas*, and *Architeuthis dux* (Fig. 4).

CONCLUSION

Cinematographic narratives carry great potential for disseminating and popularizing the impacts of human action on the environment. Also, when it comes to mal-

Figure 4. Three species of cephalopods commonly associated with dangerous and dark animals: Left: illustration of *Vampyroteuthis infernalis* (vampire squid). Top right: *Dosidicus gigas* (Humboldt squid). Bottom right: *Architeuthis dux* (giant squid). Source: Wikimedia Commons.

acology, they offer the opportunity to learn about the groups of mollusks in opposition to their fictional versions, also allowing a reflection on their diversity and preservation.

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A practical implication of the Astolfo Effect: bias in AI generated images

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Figure 1. The lovely paladorks. Fanart showing Roland (left inset), Astolfo, Charlie (a.k.a. Charlemagne), Bradamante, and Merlin (right inset). Illustration by Rabi (https://twitter.com/b_rabi; https://www.pixiv.net/users/4959742); used with permission.

The year of 2022 saw a huge advance in AI technology, especially Large Language Models, or LLMs. This culminated in the release of Chat GPT, an AI Chatbot assistant that, as of the time of this writing, is wowing the public with its uncanny performance.

However, chatbots are not the only application of LLMs. One such application is the artificial generation of images. Although such idea is not a novel one (it dates back to the 1970s; Elgammal, 2022), the advancements on large language models allowed a new breakthrough in what these methods are able to achieve.

A non-obvious application of such models is as a "probe" for bias in its learning set. Since these models are trained on public datasets collected from the Internet, they tend to reflect the inherent biases present in human generated content. As such, we see the advent of AI generated image as an opportunity to further test the 'Astolfo Effect' hypothesis, as first outlined by Tomotani & Salvador (2021).

WHAT IS THE ASTOLFO EFFECT?

We really encourage you to check out our original article and its follow-up (Tomotani & Salvador, 2021, 2022) to get the full story, but we will summarize the Astolfo Effect here.

It all starts with the *Fate* franchise, which began with the visual novel (and later anime) *Fate/stay night* in 2004 but became massively popular with the mobile and arcade versions of the game *Fate/Grand Order* (henceforth FGO; mobile version by Delightworks, Lasengle, 2014–present, and arcade version by Sega AM2, 2018–present). In the *Fate* universe, mages can summon heroic spirits (known as 'Servants') to fight alongside them or, more usually, on their behalf. The servants are almost all taken from real-world material and can be historical people, legendary/mythological beings, or literary characters.

Fate is so popular and has such an amazing quantity of fanart that, typically, if you're doing an internet search for a given character, you will get results including both "actual" real-world entries and *Fate*-related entries.

For the Astolfo Effect, we hypothesized that the most obscure characters (e.g., Astolfo and Bradamante; Fig. 1) present in FGO would, on a Google search, have more hits of their *Fate* incarnations than their original real-world ones. We further hypothesized that those FGO-related Google hits would appear sooner rather than later in the search. Conversely, widely popular characters (particularly in cinema and TV, such as Sherlock Holmes) would have fewer hits about their FGO incarnations and those would appear later in the Google search.

We have shown that the Astolfo Effect is real and provided a list of the characters most affected by this (Tomotani & Salvador, 2021). Besides the ever-lovable Astolfo, that list included servants such as Nitocris, Sitonai, Yu Mei-ren, Li Shuwen, Mandricardo, Osakabehime, Scathach, and Yan Qing.

Given that the Astolfo Effect specifically pertains to internet searches, it is expected to play a role on AI-generated images, which fully depends upon images available online. However, in the original Astolfo Effect, we were interested in how fast internet searches got "flooded" with *Fate* material and the proportion of the first results that were from *Fate*. AI will use all available material, so we must make an adjustment and come up with a corollary: in this case, we expect that the AI-generated images affected by the Astolfo Effect will be those belonging to the characters with most fanart (e.g., Astolfo, Cu Chulainn).

HOW ARE IMAGES GENERATED BY AI?

There is a lot of debate currently ongoing in the AI and Art community about the impact of this technology on the art scene, as well on the ethical and copyright implications of this technology.[1] As our goal is to seriously study the *Fate* phenomenom, we are not going to weigh in on this debate in this article.[2] Also, we will refrain from explanations that anthropomorphize AI models, such as stating that AI models "learn" a specific artist style by looking at a thousand images. They are not humans, and do not learn like humans.

The current state-of-the-art approach for generating images using AI are called diffusion models. They are a class of models that

[1] Here are some articles and viewpoints if you're interested: Guadamuz (2017), Gillotte (2020), Cetinic & Che (2022), Elgammal (2022), Plunkett (2022). There are also some fun Last Week Tonight (HBO) episodes about it too.

[2] If you are interested on the perspective of each author on this topic, see the "About the authors" section at the end of this article.

are created by adding noise to an image, and by training a neural network to predict and remove this noise from an input image. By feeding a random noise input image to the model we can generate a new image by applying this "de-noise" procedure.

In a sense, these models learn a function that approximates the joint probability distribution of pixels in the images of its training set. With that function at hand, we can sample this distribution to generate new images. And by conditioning the distribution on the image prompt we can guide the generating process, creating images that correspond to a textual input given by the user.[3]

Given that these models approximate the distribution of its training dataset, they are, of course, vulnerable to bias present in those datasets – such as the bias introduced by the Astolfo Effect. The following section describes our approach to identify and quantify this bias.

METHODOLOGY

To evaluate the bias introduced in the joint distributions learned by these kinds of Diffusion Models, we utilized "Stable Diffusion", a model trained and open-sourced by Stability AI, an AI product and consulting company. This model was trained on the LAION Aesthetics dataset,[4] a subset of the LAION-5B dataset curated to contain images that humans find "aesthetically pleasing". As the LAION-5B dataset contains over 5 billion images collected from the internet we conjectured that the Astolfo Effect bias would be present in it.

Setting up these models can be quite a hassle, as they have loads of dependencies and pre-requisites both on the hardware (GPU acceleration) and on the software (OS'es, drivers and libraries) sides. Fortunately, there are containerized docker applications that take care of all that for us. In this article we utilized the "stable-diffusion-docker" image provided by GitHub user 'fboulnois'.[5] This docker image allow us to prompt the model using a very simple command line script bundled with the docker image. For example, the following prompt produced the following image:

```
./build.sh run "An impressionist painting of a parakeet eating spaghetti in the desert"
```

Using this container, we generated images for a series of historical and mythological figures that are present in FGO, using the following command:

```
./build.sh run "{name}"
```

[3] This is a huge oversimplification. If you're interested learning more about these models, we recommend the article by Allamar (2022).

[4] https://laion.ai/blog/laion-aesthetics/

[5] https://github.com/fboulnois/stable-diffusion-docker – run the official Stable Diffusion releases in a Docker container with txt2img, img2img, upscale4x, and inpaint.

where {name} is a placeholder for the actual name of the historical or mythological figure in question. So, for example, when generating images of "Arthur Pendragon" the command used was:

```
./build.sh run "Arthur Pendragon"
```

There were no attempts at "prompt engineering" such as prompting a specific art-style or specifying that we were interested in historical or mythological figures. Only the name of the figure was given to the model.

Servants

As in Tomotani & Salvador (2021), we considered only the characters present in the mobile version of FGO (not the Fateverse as a whole), considering both the North American and Japanese servers in their state in July 2022 (last announced servants were Kyokutei Bakin and Minamoto no Tametomo). We used the North American spelling of the names (even though some are a bit "off"; see discussion in Tomotani & Salvador, 2021); for those characters that are yet to be released in North America, we used the names as given by the Fate Grand Order Wiki.[6]

We had to exclude some servants from our study, such as: repeated entries of the same character (e.g., Alter/Summer/Prototype/etc. versions); original characters (Mash, Emiya); and servants that were based on real-world material but in a way that makes them exclusive to the Fateverse (Hessian Lobo, Kijyo Koyo, Senji Muramasa).

RESULTS

In total, we had 199 servants, and the full set of images can be found in the Supplementary File to this article. The majority of the images produced was based on either (1) photographs or still images from films/TV series, or (2) "classic" art (mostly paintings, but also illustrations and sculptures). But many of the AI-generated images were affected by the Fateverse to different extents, from completely (e.g., Astolfo, Cu Chulainn) to tangentially (e.g., Euryale, Gilgamesh).

Here's the full list of affected characters (see Fig. 2 for the images): Astolfo, Astraea, Bedivere, Bradamante, Cu Chulainn, Enkidu, Ereshkigal (not shown here because it was NSFW), Euryale (the purple hair gives it away), Gilgamesh, Ishtar, Iskandar (looks mostly like a classic artwork, but his anime eyes are priceless), Jing Ke, Kiyohime, Mordred, Nero Claudius, Osakabehime (shown in the typical pose of the official artwork, but what the hell happened here?), Scathach (also influenced by her incarnation in *Shin Megami Tensei* and *Persona* games), Semiramis, Sitonai, Tamamo no Mae, and Yan Qing (also not shown due to NSFW reasons).

Most of the lesser-known servants from the results of Tomotani & Salvador (2021) that we mentioned earlier also popped up on the present list. But, as predicted, better-known characters (or characters with several other representations) also make the list if they are popular enough to have tons of fanart: Euryale, Gilgamesh, Ishtar, Iskandar, and Mordred.

Other odd stuff

Curiously, it was also possible to see the influence of other pop culture icons on some results (Fig. 3). For starters, Baobhan Sith, because of the term "Sith", was rendered as an evil-looking *Star Wars* character. Lu Bu and Sima Yi's image were affected by their more famous incarnations from the *Dynasty Warriors* video game series. Astraea (Fig. 2), Habetrot, Hektor and the Valkyries were illustrated as cards from *Magic: The Gathering*. Eric Bloodaxe, the always-forgotten

[6] https://gamepress.gg/grandorder/servant-availability

Figure 2. AI generated images that have been affected to varying extents by the Astolfo Effect.

Figure 3. AI-generated images that have been affected by other things.

character in FGO, also appears as a card, potentially based on the game *Anachronism*. Chen Gong was part of an image that looks like a character/monster entry from a *Dungeons & Dragons* book, complete with depictions of the stats and text blocks. Nemo, of course, was shown as a clown fish. Siegfried appears as a bad Manowar-style heavy metal album cover art (perhaps based on the magician duo Siegfried & Roy).

Finally, Himiko, Izumo no Okuni, Minamoto no Tametomo, Ranmaru, Saito Hajime, Sakata Kintoki, Suzuka Gozen, and Watanabe no Tsuna were clearly based on manga/anime aesthetics, though not related to *Fate*. Saito Hajime's image, in particular, was influenced by his many other manga/anime incarnations, which are generally more popular than FGO's one.

CONCLUSION

Salvador (2020) remarked that in all likelihood, many historians, archaeologists, and literary scholars must have at some point cursed *Fate* when their Google searches brought up a flood of anime results (sometimes NSFW!). Our results show that AI are also affected by this and, thus, we extended the known sphere of influence of the Astolfo Effect.

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Supplementary File

Full set of AI-generated images created during the present study.

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We are extremely grateful to Rabi for letting us reproduce here the amazing artwork of chibi Charlie and his paladins.

About the authors

Dr **Rodrigo B. Salvador** was until recently a curator at the Museum of New Zealand Te Papa Tongarewa and now is a researcher in the Arctic University Museum of Norway. He believes the world would be a better place without so many tech bros. He is notably unlucky in summoning SSR servants, so he is seriously considering visiting Aachen next year to use the Throne of Charlemagne as a catalyst.

Henrique M. Soares is an independent researcher from Brazil and fortunately was never hooked by the "gacha" demons. He believes AI generated images are not artwork, but a tool to further aid artists, and that safeguards must be put in place to protect the rights of artists to their creations (although he has no idea what such safeguards might be).

João Tomotani, MSc, is an engineer and Rin simp since the 2006 FSN anime, who seems to be turning into an Astolfo Effect specialist. Despite never having researched or delved into AI topics, the sheer amount of AI-generated FGO fanart being recommended to him has caught his attention. He successfully pulled Space Ishtar this year completing his Rin collection, and is now in the gigantic camp waiting for a new version of Ereshkigal (no, a costume is not enough).

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The lure of the deep sea: anglerfish as movie monsters

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Figure 1. A deep-sea anglerfish, *Cryptopsaras couesii*. Image extracted from Miya et al. (2010: fig. 2B).

With its lure and sharp teeth, the anglerfish (Order Lophiiformes) is the iconic deep-sea monster. In this article we consider the aesthetics, morphology, and scientific background behind four anglerfish and anglerfish-inspired monsters in film: the Opee Sea Killer in *Star Wars Episode I: The Phantom Menace* (1999), the Ice Cream Lady in *The Sponge Bob Square Pants Movie* (2004), the anglerfish in *Finding Nemo* (2003), and Uncle Ugo from *Luca* (2021).

Anglerfishes are an order of bony fish (teleosts) named in homage to their conspicuous use of bioluminescent lures to ensnare prey (Fig. 1). Shallower water anglers, such as the monkfish, use lures but are perhaps not as iconic as the deep-sea mesopelagic anglerfish. Luring as a method for feeding occurs in both the plant and animal kingdoms (Pietsch & Grobecker 1978). This method is effective in conserving energy by remaining motionless and enticing potential predators by what appears to be their typical prey, only for the predator to become the prey. Lures can come in many guises, with some mimicking food, others enhanced by exhibiting prey-like behaviour, even some emitting false sexual cues.

Deep-sea anglers live in the deep-pelagic zone of the ocean, typically at depths between 200 and 1000 m where the last remnants of solar light are detectable (Sutton, 2013). This is often referred to as the 'twilight zone' (Warrant & Locket, 2002). A prerequisite for survival in the deep pelagic is therefore survival at ultra-low light levels. Such strategies include avoiding being preyed upon, preying upon others without being seen, communicating without being detected by adversaries and selecting the correct sexual partners. All of these can be achieved through the manipulation of biologically derived light or 'bioluminescence' which is essentially a chemical reaction involving a light-emitting molecule (luciferin) and an enzyme (luciferase). Bioluminescence has many uses, including camouflage in downwelling light, mimicry, stunning or confusing predators, to attract mates, and many others (Haddock et al., 2010).

It is the lurk-and-lure combination of behaviour and morphology that make the deep-sea anglerfish one of the true masters of light in the deep sea. In 10 of the 11 families of anglerfishes, the females have a bulbous luminous lure (the esca; Herring, 2007). The males lack such a lure and therefore the ability to produce bioluminescence is restricted to the females (Bertelsen, 1951). The esca is a complex structure that can have numerous protuberances, filaments, and reflector systems, and is suspended from the body by a long modified dorsal fin ray (the illicium or 'fishing rod'). Symbiotic luminous bacteria are contained within the bulb of the esca and are exposed to the exterior by a pore, allowing the host to control the emission of light. It is generally assumed that females of all anglerfishes have this light-emitting capability. The movement of the lure, which mimics the movement of the prey, adds to its 'fishing' function (Pietsch & Grobecker, 1978).

The lurk-and-lure combination is an energy conserving strategy in a food impoverished environment. The bodies of anglerfish are rather bulbous and flabby with spiked ragged fins that differ from those of more familiar shallower species as they are used primarily for stabilization rather than locomotion. Anglerfish are however capable of burst swimming albeit in a lethargic manner. Their jaws and stomachs can extend to consume prey much larger than itself, a strategy common in scavengers and predators in low food environments. They typically have very small eyes, and blackened bodies which are typical adaptations to living in low-light environments.

Anglerfish such as the Ceratiidae or sea devils also exhibit extreme sexual dimorphism, with females being much larger than the males (Pietsch, 1977). The males are often highly reduced parasitic dwarves, evolved to partake in an unusual mating strategy. They are polyandrous, with the female taking two or more male sexual partners simultaneously. For some anglerfish species to reproduce, the male will fuse with the female which is only possible due to the lack of immune system keys that permit maturation of antibodies and the production of T-cells, which would normally cause the female's immune system to reject the male (Swann et al., 2020). The parasitic dwarf males hatch with well-developed olfactory organs and large well-developed eyes to detect the scent and light from females in the darkness of the deep sea (Carazo, 2022). Some males are thought to be incapable or relatively ineffective at feeding and therefore never fully mature without fusing with a female. The male must, therefore, quickly find a female to survive.

The combination of the black body, beady eyes, big mouth, long sharp teeth, and the effectively invisible 'creature' lurking in the void accompanied by a small drop of dancing light is a powerfully evocative image of the deep sea and its dangers. It is the deep-sea anglerfish's unusual lifestyle, unsettling morphology and how these are both intrinsically linked to the terrors of the abyss that makes them such an iconic ambassador of the deep sea. While many films draw upon the anglerfish to evoke deep-sea alterity and therefore the danger presented to the protagonists, however, scientific accuracy tends to take a backseat in comparison to creating spectacle, with many anglerfish-inspired monsters being Frankensteinian assemblages of parts taken from multiple different animals.

OPEE SEA KILLER

The Opee Sea Killer is an aquatic monster that pursues Qui-Gon Jinn, Obi-Wan Kenobi, and Jar-Jar Binks in a Bongo

Figure 2. Opee Sea Killer. Source: *Star Wars Episode 1: The Phantom Menace* (Disney+, screen capture).

through the planetary core of Naboo (Fig. 2). An annotated description of the animal details its "bizarre amalgam of traits ordinarily found only in a range of disparate creatures" (Reynolds, 1999). Morphologically the Opee Sea Killer has 'multidirectional eye stalks' more akin to a chameleon (Family Chamaeleonidae) than a deep-sea fish (Ott, 2001). Similarly, it is capable of ballistic projection of a sticky tongue in the same manner as a chameleon (Moulton et al., 2016). Otherwise, most of its traits are drawn from deep-sea species.

The Opee Sea Killer has twin bioluminescent lures on the end of two illicia that run from the dorsal position at the anterior to beyond the length of the body. The Opee clings within dark crags, using the lures on its head to draw the attention of potential prey (Reynolds, 1999), much as the same as female deep-sea angler do in the deep pelagic (Young, 1983). It is therefore likely that it can swing the lures in front of it, adopting the 'lurk-and-lure' strategy (Herring, 2001). Double (bifurcated) lures are observed in some species e.g., *Himantolophus albinares*, but only on one illicium (Iglésias, 2005). While lures are common among deep-sea anglerfish, the illicium that dangles the lure in front of the mouth are formed from tissue from a modified dorsal fin ray (Caruso, 2002) and therefore if there were ever two, they would likely both in the midline given this ontogeny, not side by side.

The large gaping mouth that it uses to gulp prey attracted to the bioluminescent lure is a common feature in deep-sea anglers as they dwell in an environment where food is very sparse, meaning that little effort is expended in hunting and prey size is maximised (Herring, 2001). The Opee Sea Killer also features prominent pectoral fins "for guidance" (Reynolds, 1999) which are of similar morphology as the coelacanth, *Latimeria chalumnae*, an ancient group of lobe-finned fish (Sarcopterygii, Class Actinistia), not typical of benthic or pelagic fish species (Miyake et al., 2016).

The back half of the Opee Sea Killer resembles that of the giant isopod *Bathynomus giganteus* (Family Cirolanidae) (Soto & Mincarone, 2001). This is evident in the pereon (thorax) on the dorsal side that is made up of segmented pereonites. The Opee Sea Killer, however, lacks the pleon at the posterior end. Its pereonites are serrated rather than smooth edged as seen in the giant iso-

Figure 3. Ice Cream Lady. Source: *The SpongeBob SquarePants Movie* (Netflix, screen capture).

pod. The tail legs, which "drive water and help the Opee Sea Killer cling motionless in rocky crags waiting for prey" have crustacean pereopod morphology similar to the uniramous pereopods of the giant isopod, but with only 3 sets. While their effectiveness at clinging to rocks is believable, their ability to 'drive water' is doubtful: in giant isopods this is mostly done using the pleon that is absent in the Opee Sea Killer, albeit other isopods are known to "walk through water" using modified pereopods (Marshall & Diebel, 1995).

In addition to swimming with its legs, the Opee Sea Killer uses jet propulsion by sucking in water through its mouth and emitting it through opening under the plates (pereonites). This trait does not exist in fish or crustacea, but the basic concept is seen in squid (Staaf et al., 2014). According to Lucasfilm Conceptual Researcher Jonathan Bresman, the Opee Sea Killer was initially intended to be "essentially a huge jaw grafted onto a fish/crab body" but became "more of a cross between an angler fish and a crab" (Reynolds, 1999). The Opee Sea Killer is a multi-animal amalgamation with a chameleon's head and ballistic tongue, the gaping mouth and bioluminescent lure of a female deep-sea angler fish, the body and legs of a giant isopod, the pectoral fins of a coelacanth, and the locomotion of a squid.

ICE CREAM LADY

The concept of an anglerfish-like antagonist with certain chameleon-like characteristics continues in *The SpongeBob SquarePants Movie*. Sponge Bob and Patrick venture out of Bikini Bottom into a boneyard where they encounter an old lady selling ice cream (Fig. 3). When SpongeBob attempts to take the bowl of ice cream it sticks to his hands and the ground breaks away to reveal that he is standing in the gaping maw of a huge red fish whose lure is a protrusion on its tongue. The monster largely possesses elements of the anglerfish, yet the 'sticky' tongue is also, more akin to that of a chameleon (Moulton et al., 2016). This particular representation of the anglerfish draws upon the features of demersal species, that is, species that are associated with the seafloor rather than the pelagic mid-waters. This is evident in the placement of the esca and the locomotion of the fish itself.

Not all deep-sea anglerfishes have the esca suspended above the head on the illicium. Anglerfish of the genus *Thaumatichthys* or 'wolftrap seadevils', such as Prince Axel's wonderfish (*T. axeli*) are benthic

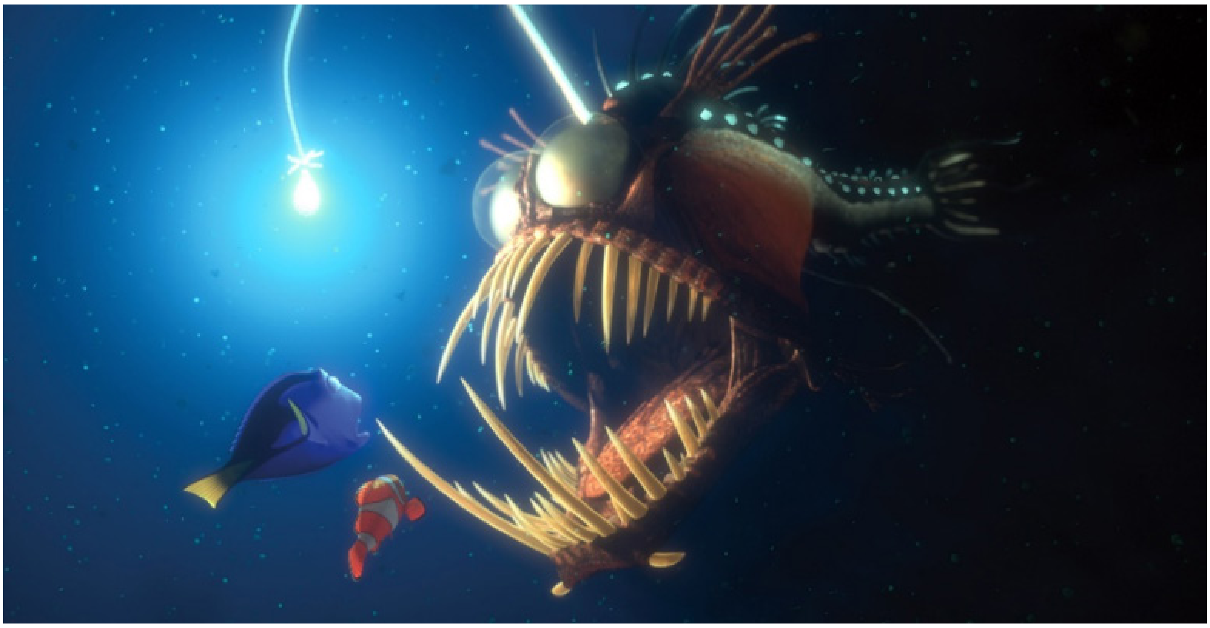

Figure 4. Deep-sea anglerfish. Source: *Finding Nemo* (Disney+, screen capture).

species in the Thaumatichthyidae family. While the pelagic species use the bioluminescent lure to mimic a small prey item suspended or swimming in the midwater, the benthic species have adapted lures that resemble something more typically benthic, i.e., sessile. Instead of suspending its lure in the water column, Prince Axel's wonderfish sits motionless on the seafloor and lures prey with a distinctive forked esca on the roof its mouth (Bertelsen & Struhsaker, 1977). Early observations referred to it as "the trap-mouthed wonderfish" (Gromova & Makhotin, 2022). Female *Thaumatichthys* have a long, broad, flattened head with enlarged premaxillary teeth on the upper jaw that overhang the shorter lower jaw. The jaws are hinged in such a way that the upper jaw with the longer teeth can be lowered down to enclose the lower jaw, which is how the fish attempts to eat SpongeBob.

Once the lure is revealed to be a trap and the whole body of the fish emerges from the benthos, it chases SpongeBob on foot. While this seems strange, "walking" is not uncommon in some demersal anglerfish. Monkfish (*Luphius piscatorius*) walk across the seabed using a combination of both the pelvic and pectoral fins, with the pelvic fins bearing weight and both generating propulsion and aiding in stability (Angus, 2003). Other fish, such as frogfishes are known to 'walk' (Pietsch & Grobecker, 1990). The Ice Cream Lady can therefore be described as a demersal anglerfish with an oral lure (but on the floor of the mouth rather than the roof), with a sticky chameleon tongue. This character is more comical and combines less disparate features in comparison to the Opee Sea Killer, but still behaves as the jump scare antagonist. It is slightly more developed as a 'character' as opposed to simply a 'monster', like the Opee, albeit in the somewhat bizarre guise of a sentient lure masquerading as an old lady selling ice cream on the outskirts of the city.

FINDING NEMO'S ANGLERFISH

Marlin and Dory descend into a deep-sea trench to find a scuba mask, on which is written the address where Nemo was taken. In the trench they are captivated by a light, which is then revealed to be the bioluminescent lure of an anglerfish (Fig. 4). While its general body morphology, colour, long thin teeth, gaping mouth and single bioluminescent lure are very in keeping with the generalised model of a female deep-sea angler fish, other elements are drawn from other species (Anderson & Leslie, 2001). For ex-

Figure 5. Uncle Ugo. Source: *Luca* (Disney+, screen capture).

ample, anglerfish in the deep sea are known for having very small eyes relative to the body, but the anglerfish in *Finding Nemo* has large, soulless eyes. These eyes are much more binocular, and in fact resemble the eyes of the binocular fish *Winteria telescopa* or the large cloudy domed eyes of the barrel-eye *Macropinna microstomsa* (Wagner et al., 2022). The unsettling eyes paired with the fact that the anglerfish does not speak renders it significantly less anthropomorphised in comparison to the expressive, talking fish that populate the rest of the film.

The anglerfish illuminates its array of photophores which are typical of mesopelagic species such as the hatchetfish *Argyropelecus hemigymnus* (Krönström et al., 2005). This type and arrangement of photophores have evolved to provide camouflage against the downwelling solar light from the surface when viewed from below by mimicking the light intensity with bioluminescence emitted by the photophores on the ventral surface (Herring, 2002). However, in the anglerfish in *Finding Nemo*, these photophores are on the dorsal surface meaning that they would never work as camouflage: quite the opposite. Photophores on the dorsal surface would illuminate the fish against the dark surroundings when viewed from above and would still be visible through its silhouette, perhaps even enhancing it if viewed by a predator from below. However, in addition to the esca, females of some anglerfish species have sacs (caruncles) containing luminous bacteria on the dorsal surface, but usually only 2 or 3 situated in front of the dorsal fin (Munk & Herring, 1996).

The lurk-in-the-dark jump scare moment in *Finding Nemo* in which the fish behind the lure lights up is enhanced by equipping the anglerfish with features from other distinctive deep-sea morphologies. Despite being the only ‘realist’ text in this article in which fish are ostensibly based on real species, the anglerfish’s morphology is fantasy.

UNCLE UGO

Luca’s Uncle Ugo is a sea monster who lives in the deep sea and subsides on a diet of whale meat. In contrast to Luca’s rational and loving immediate family members, who are brightly coloured with expressive eyes, Ugo is a somewhat unhinged and unsettling character estranged from the family (Fig. 5). Unlike the Opee Sea Killer or the *Finding Nemo* Anglerfish who are obstacles for the protagonists of their respective films, Uncle Ugo is a character with his own personality and reasons for his quirks. However, his association with the deep sea still associates him with alterity. On first appearance Uncle Ugo is a clumsy humanised representation of morphologies from many families of fish (with additional exotropia), however, he has two physical elements that place him strictly within the deep-sea fishes.

Based purely on morphology, Ugo is obviously deep-sea fish-inspired because of the bioluminescent lure on top of his head that even illuminates his face while he speaks. The combination of the lure suspended on the illicium in front or above a wide mouth with sharp teeth is the common anglerfish feature, however, the presence of the lure technically makes Uncle Ugo a female (Herring, 2007). If we assume sea monsters conform to contemporary Western configurations of gender construction, Uncle Ugo might be considered trans or intersex.

When he visits Luca's family his heart stops due to the increased oxygen levels of the water, and Luca must punch him in his transparent chest to save him. This provides two further connections with the deep sea. Firstly, his intolerance of ambient oxygen levels in the shallow seas suggest he is adapted to low oxygen levels that are typically found in the oxygen minimum zones (OMZs) of the ocean (Paulmier & Ruiz-Pino, 2009). OMZs are where oxygen saturation in seawater is at its lowest which typically occurs at depths of ~200 to 1500 m but can vary regionally but are found worldwide. Uncle Ugo is from the Italian Riviera (Liguria) in the Ligurian Sea region of the Western Mediterranean. Oxygen in the surface waters is between 200 and 240 μmol/kg but decreases rapidly to ~190 μmol/kg by 400 m (Mavropoulou et al., 2020). Therefore, if he struggles with oxygen in the surface waters, he is likely to be from depths ~400 m. This puts him either on the continental slope or in one of the 2 canyons: the Polcavera or Bisagno Canyons.

Ugo's transparent body may have been inspired by the gelatinous encapsulation of the head of the barrel-eye fish, which has a completely transparent head (Wagner et al., 2022). However, the reference to Ugo's visible heart suggests transparency of the main body, which can be common in some deep-sea fish families. Beyond the larval phase, there are not many deep-sea fish that are as transparent as Ugo who is presumed to be fully mature. The deepest fish in the ocean, the hadal snailfish (Liparidae), are largely transparent where internal muscles and organs are visible through the gel-like sub-dermal extra cellular matrix (Gerringer et al., 2017). This 'gel' offers a solution to help in obtaining neutral buoyancy and hydrodynamic streamlining without maintaining expensive tissues, such as skin and scales, in a food scare environment.

The deep waters off the Italian Riviera happen to underly the "Santuario dei Cetacei" or Cetacean Sanctuary. This explains why Ugo has a penchant for whale meat and allows audiences to further make the connection with the deep sea, of which whale falls are a well-known feature (Smith & Baco, 2003). There is a plethora of deep-sea species who will exploit whale fall carcasses (Smith et al., 2015); however, Uncle Ugo is morphologically unsuited to scavenging due to his bioluminescent lure, illicium and gaping mouth. His lure marks him as a pelagic lurk-and-lure predator, not a scavenger. These inconsistences are perhaps part of the inexplicably complex character of Uncle Ugo. In comparison to anglerfish discussed above, Ugo actually has a personality and shows kindness to Luca, even if Luca is not convinced. However, his association with the deep-sea prescribes a portrayal as ugly, ill-coordinated, and obtuse. His off-putting quirks and description of his deep-sea home ultimately convince Luca to run away from his family and live on land—it would be a very different film if Luca had been more curious about the deep sea.

DISCUSSION

Based on our assessment of four different anglerfish in film, we draw some broader observations about the role they play in popular culture. The anglerfish, identifiable by its iconic lure, is a powerful representative of deep-sea alterity. When anglerfish are represented in visual media, they are rarely based off a singular species and instead take the scariest features from multiple creatures, including non-aquatic features, sacrificing scientific accuracy for spectacle. This happens regardless of whether the text is speculative (science fiction and/or fantasy) or realist (based on real places and things).

Anglerfish, as well as deep-sea animals/monsters more broadly, demonstrate a significantly lessened degree of anthropomorphism than the non-deep-sea animals in any given text. When assigned any gendered attributes, anglerfish tend to present as male. This is likely a manifestation of an underlying patriarchal ideology that sees femininity as incompatible with ferocity and therefore monstrosity (Ferguson, 2018). Another example is this can be found elsewhere in *Finding Nemo*. Bruce the Great White shark is a male character who flips between being a kind and pleasant jokester and a mindless carnivorous monster, appears to lack claspers and is therefore morphologically a female. While anglerfish are certainly a powerful icon of the deep-sea and its depths, there is a distinct lack of scientific accuracy in on-screen Lophiiformes. This goes hand-in-hand with the lack of sympathetic representation. Anglerfish may seem scary, but they are just trying to do what all fish do: eat, mate and survive.

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From reality to fiction: cnidarians that inspire the Pokémon world

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Pokémon is a franchise that has taken inspiration from inanimate objects and living things to design a variety of creatures. Among those living beings are the cnidarians, very peculiar animals that have inspired the design of the coral and jellyfish Pokémon, which represent 1.44% of the 1,008 creatures created for the franchise so far (The Official Pokémon Website, 2023).

The phylum Cnidaria is composed of 13,300 species of invertebrate animals (Kayal et al., 2018), characterized by specialized cells that produce poison inside of minuscule capsules, known as cnidocysts (Tardent, 1995). Cnidarians are mostly aquatic and live in the sea, rivers, or lakes (Slobodkin & Bossert, 2010). Their body plan can manifest as polyps (mostly sessile phase) or jellyfish (mostly motile phase) (Slobodkin & Bossert, 2010). This phylum is divided into three large taxonomic groups (or subphyla) and, according to their order of appearance in the evolutionary time, are: Anthozoa, Endocnidozoa, and Medusozoa (Daly et al., 2007; Kayal et al., 2018).

WHO ARE THE CNIDARIANS?

The subphylum Anthozoan (Fig. 1) is composed only of polyps, that is, animals that usually live attached to a substrate and never produce jellyfish during their life cycle (Otero et al., 2017). The anthozoan polyps can remain solitary or live in colonies (Daly et al., 2007).

This subphylum is divided into three classes: Hexacorallia, Octocorallia, and Ceriantharia (Kayal et al., 2018; Ceriello et al., 2020). Hexacorallia comprises scleractinian corals (order Scleractinia) and anemones (order Actinaria). Scleractinian corals, also known as stony corals, have a skeleton made of calcium carbonate and are quite relevant as reef-building corals, while anemones have a disc bottom to attach themselves to several kinds of substrates and have a wide array of colorations (Daly et al., 2003).

Octocorals, on the other hand, do not have a calcium-carbonate skeleton, and for this, they are called soft-corals (order Alcyonacea). Species in this group form colonies, and one important characteristic is that their tentacles are always arranged in groups of eight, hence their name (Fabricius & Alderslade, 2001). Lastly, tube-dwelling anemones of the subclass Ceriantharia are solitary animals that bury themselves in sediments and live inside tubes for protection (Daly et al., 2007).

Endocnidozoa comprises parasites, with approximately 2,200 species belonging to the taxonomic classes Myxozoa and Polypodiozoa (Kayal et al., 2018). Myxozoans are ameboid parasites of both invertebrates and vertebrates, characterized by the presence of polar capsules, which contain an extrudable filament with an anchoring function, similar to nematocysts (Lom & Dyková, 2006). *Polypodium hydriforme* is the only species included in Polypodiozoa; it is adapted to intracellular parasitism in the oocytes of fishes and affects commercially important fish species such as black caviar (Raikova, 1994).

Some species of Medusozoa may exhibit the polyp life stage (Pantin, 1960). However, this subphylum is characterized by the

Figure 1. Cnidarian diversity. Subphylum Anthozoa: **A.** Hexacorallia hard-corals of Scleractinia (T. Hudson; CC BY-SA 3.0). **B**. Hexacorallia anemone (N. Hobgood; CC BY-SA 3.0). **C.** Octocorallia soft-corals (A.M. Gabriela, J.K. Belén & R.J. Antonia; CC BY SA 4.0). **D.** Octocorallia sea pen (S. Shebs; CC BY-SA 3.0). **E.** Cerianthiaria solitary anemones (L. Ilyes; CC BY 2.0). Subhylum Endocnidozoa: **F.** Polypodiozoa (E.V. Raikova; CC BY 2.0). G. Myxozoa (M. Ahn, H. Woo, B. Kang, Y. Jang & T. Shin; CC BY 4.0). **H.** Myxozoa (public domain). Source of all images: Wikimedia Commons.

jellyfish stage (Marques & Collins, 2004) (Fig. 1). Generally representing the mobile life stage, jellyfish tend to be free-swimmers (e.g., cannonball jellyfish *Stomolopus meleagris*; Shanks & Graham, 1987). The jellyfish body plan is made up of three main parts: the umbrella, named like that because it resembles one; the manubrium, constituted by a tube under the umbrella in which the mouth is located; and the tentacles, which are long and very flexible appendages arising from the edge of the umbrella or the mouth of the jellyfish, the latter known as oral arms (Russell, 1953). Among jellyfish, there is a diversity of sizes, some species can be a few millimeters long, while others reach up to 36 meters (Larsen, 2016).

The subphylum Medusozoa is divided into four taxonomic classes: Staurozoa, Cubozoa, Scyphozoa, and Hydrozoa. Stauromedusae (Staurozoa) are characterized by being sessile organisms fixed to a substrate through a peduncle (Miranda et al., 2016). Box jellyfish (Cubozoa) are characterized by complex eyes (e.g., *Tripedalia cystophora*; Coates, 2005), high toxicity, and a highly acute sense of direction (e.g., the sea wasp *Chironex fleckeri*; Kintner et al., 2005; Gordon & Seymour, 2009). Scyphomedusae (Scyphozoa) are the most widely known jellyfish; some species can reach large sizes, and their agglomerations can alter the marine environment and negatively impact activities of economic relevance (Purcell et al., 2007). Finally, hydromedusae (Hydrozoa) are distinguished from other jellyfishes due to their small size and the presence of the velum, a structure located within the umbrellar margin (Genzano et al., 2014). Furthermore, an additional life stage called siphonophore is present, which is a combination of polyps and modified jellyfish (Mapstone, 2015).

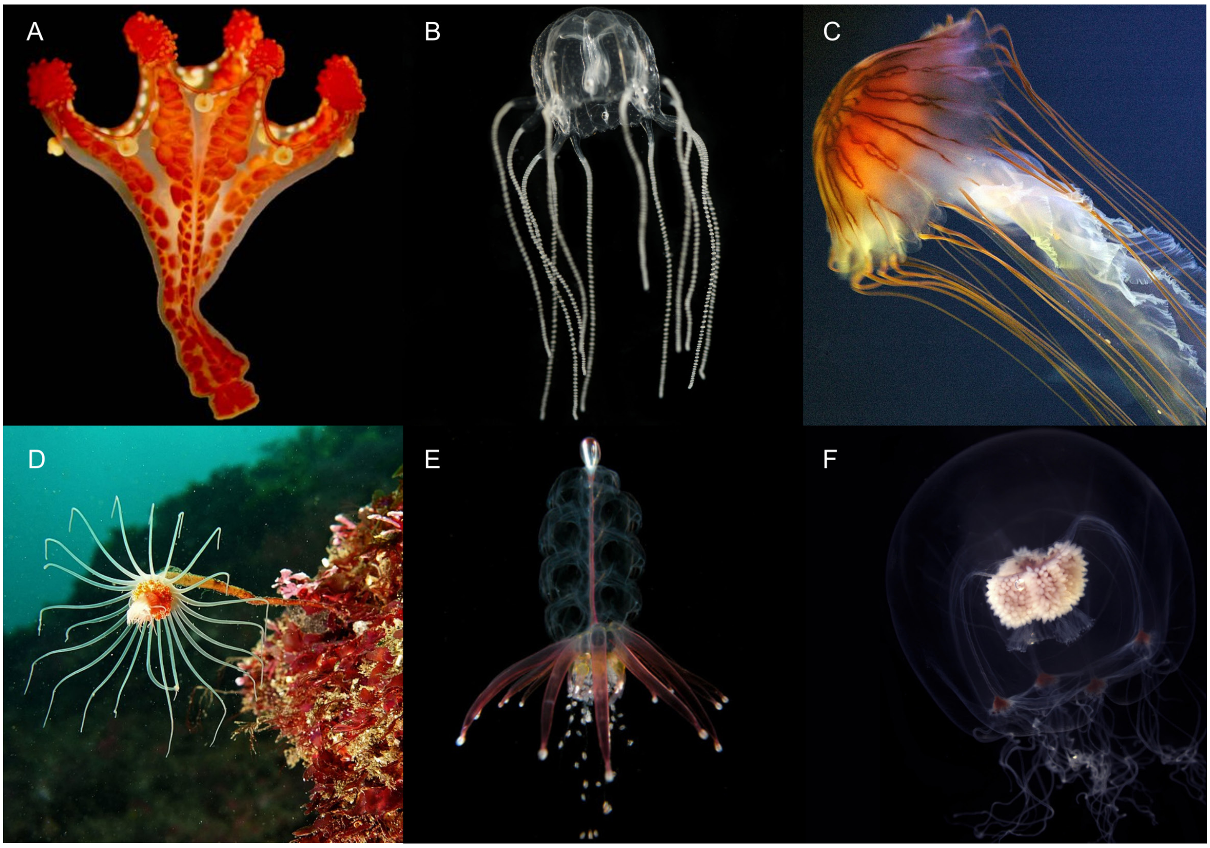

Figure 2. Cnidarian diversity. Phylum Medusozoa: **A.** Staurozoa jellyfish (C. Allen; CC BY-NC 4.0). **B.** Cubozoa jellyfish (J. Bielecki; Smithsonian Science Public Domain). **C.** Scyphozoa jellyfish (F. Degli Angeli; CC BY-SA 2.0). **D.** Hydrozoa polyp (J. Turnbull; CC BY-SA 2.0). **E.** Hydrozoa Siphonophorae (C.W. Dunn; CC0 1.0). **F.** Hydrozoa jellyfish (Pinetreella; CC BY-SA 4.0). Source of all images: Wikimedia Commons.

CNIDARIAN POKÉMON

Corals

There are two Pokémon that are inspired by real corals (Fig. 3). Corsola (#222), from the Johto region, is a Water/Rock Pokémon with regenerative abilities that inhabits warm sea waters. Another version of Corsola is the one from Galar, a ghost-type Pokémon that evolves into Cursola (#864). Galarian Corsola is Ghost-type because it became fossilized due to the impact of a meteorite in the Galar region (The Official Pokémon Website, 2023).

The morphology of Corsola is reminiscent of the Anthozoa group, particularly the corals. Corsola's design is likely inspired by the order Scleractinia, which is known for its stony or hard corals (Otero et al., 2017), furthermore it could resemble branches of the longhorn hydrocoral (*Janaria mirabilis*), a polyp that belongs to Medusozoa and each colony has a hermit crab of the family Paguridae as a symbiont (Cairns & Barnard, 1984). The regenerative capacities of Corsola are a characteristic shared among cnidarians, which is possible thanks to tissue plasticity and the presence of multi- and pluripotent cells (Luz et al., 2021). Examples of highly regenerative corals among the scleractinians are the species *Tubastraea coccinea* and *T. tagusensis* (Luz et al., 2018). Being distributed in warm waters, Corsola can be considered a hermatypic stony coral, which forms coral reefs in symbiosis with photosynthetic dinoflagellates called zooxanthellae, so its distribution is limited to the photic zone of tropical areas (Cairns & Stanley, 1982; Veron, 1995).

The appearance of Galarian Corsola and Cursola can be associated with three biological processes. Fossil corals remain as white-like calcareous structures. On the other hand, living representatives of hermatypic corals can lose their zooxanthellae algae, therefore the pigments that give them color, due to bleaching phenomenon associated with fast changes in temperature, salinity, and light exposure, as well as diseases, and the coral could perish (Brown, 1997), just as Cursola. Also, as a counterpart for hermatypic corals, there are the so-called ahermatypic corals distributed in cold waters between 4 and 20°C and at depths from zero to 6,200 m (Cairns & Stanley, 1982), which tend to look colorless. Some ahermatypic corals, such as the white coral species *Lophelia pertusa*, are reef-building and form associations with many marine species (Rogers, 1999).

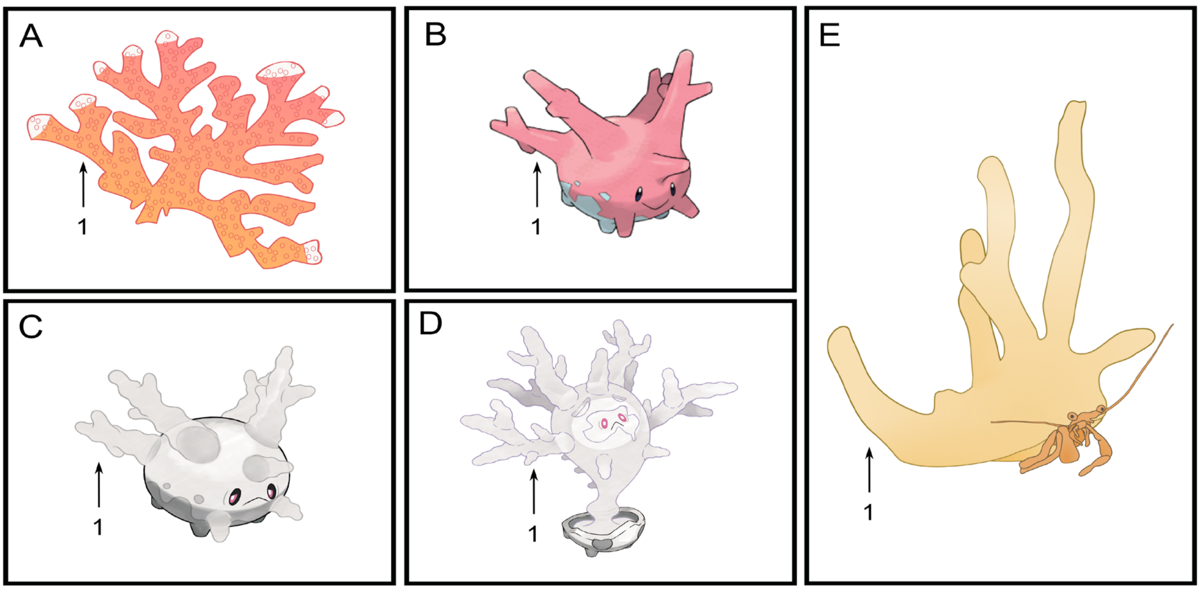

Figure 3. Corals and the Pokémon inspired by them. **A.** Anthozoa: hard branched coral. **B.** Corsola. **C.** Galarian Corsola. **D.** Cursola. **E.** The longhorn hydrocoral *Janaria mirabilis* living on a hermit crab (illustration inspired on O. Aburto; CC BY-NC 3.0). Pokémon designs are official artwork from the franchise (The Pokémon Company, 1996–2023).

Jellyfish

Currently, there are five Pokémon that resemble jellyfish (Fig. 4). The first jellyfish Pokémon introduced in the franchise were Tentacool (#072) and its evolution Tentacruel (#073), from the Kanto region. Tentacool and Tentacruel are Water/Poison Pokémon, which are consistent with the biology of jellyfish since they are aquatic and have nematocysts that inject poison and whose function is defense and capturing prey (Tardent, 1995).

The Pokédex indicates that Tentacool has two tentacles and is not a formidable swimmer, drifting in shallow water while capturing prey. On the other hand, Tentacruel has eighty tentacles that can stretch and shrink freely, trapping prey in a web of extended tentacles while delivering poisonous stings to its preys (The Official Pokémon Website, 2023). Several jellyfish species spend most of their lives floating horizontally near the ocean surface and can actively change their orientation according to ocean currents, as in the case of the barrel jellyfish (*Rhizostoma octopus*), while there are species that live at depths of up to 7,000 meters, such as the helmet jellyfish (*Periphylla periphylla*) (Jarms et al., 1999; Fossette et al., 2015). There are also jellyfish that can remain attached to a variety of surfaces, such as the clinging jellyfish (*Gonionemus vertens*), which can adhere to phytal substrates by means of its tentacles (Bakker, 1980).

Concerning the number of tentacles, jellyfish such as the purple sail *Velella velella*, has two tentacles (Brinckmann-Voss, 1970), and the small hydrozoan *Proboscidactyla flavicirrata* is known for having between 40 and 80 tentacles and its feeding strategy is to remain motionless in the water column with its tentacles extended (Mills, 1981). However, prey capture strategies vary between jellyfish species, and their effectiveness may be determined by factors such as the number of tentacles, musculature, jellyfish speed, swimming patterns, size, and prey speed, among others (Mills, 1981; Katsuki & Greenspan, 2013).

Tentacruel has red spheres on its head that glow brightly when it wants to attack, launching ultrasonic waves (The Official Pokémon Website, 2023). Tentacruel's ability to glow may be inspired by bioluminescent jellyfish, such as the helmet jellyfish (*Periphylla periphylla*) and the crystal jelly (*Aequorea victoria*), belonging to the classes Scyphozoa and Hydrozoa, respectively (Jarms et al., 2002; Haddock et al., 2010). The shiny version of Tentacruel has green spheres instead of red, such as the crystal jelly, a hydromedusa with medical relevance because GFP (green fluorescent protein) is obtained from it (Chalfie, 1995), facilitating the study of neural networks and synaptic connections (Zimmer, 2002).

Frillish (#592) and its evolution Jellicent (#593), from the Unova region, are Water/Ghost Pokémon composed entirely of seawater that catch prey with their tentacles (Pokémon official website, 2022). The water content in jellyfish is extremely high, reaching more than 95% of their total body weight, while less than 1% of their weight is carbon (Lucas et al., 2011).

Both Frillish and Jellicent have sexual dimorphism, which means that males and females of the same species have a different appearance, the most obvious example is the blue and pink colors distinctive for males and females. Nevertheless, dimorphism is not an easily distinguishable trait in jellyfish: their gonads exhibit slight variability in shape and color that could go unnoticed to the human eye (e.g., box jellyfish *Copula sivickisi*) (Lewis et al., 2008). The appearance of Frillish and Jellicent is reminiscent of the so-called common jellyfish of the class Scyphozoa, particularly the Ulmariidae family, to which the common moon jellyfish (*Aurelia* spp.) belongs.

An interesting feature of Jellicent is that during the full moon, it forms groups on the sea surface, waiting for its prey (The Official Pokémon Website, 2023). Around the world, species of box jellyfish belonging to the genus of sea wasps *Alatina* (e.g., *Alatina moseria*, *A. mordens*, and *A. alata*) have been observed forming aggregations of hundreds to thousands of individuals during reproductive events, appearing between 8 and 10 days after the full moon (Lawley et al., 2016).

Another jellyfish Pokémon is the mysterious Nihilego (#792) from Gen. VII, a Rock/Poison Ultra Beast that has an extremely powerful neurotoxin used to control people and Pokémon (The Official Pokémon Website, 2023). Jellyfish venom does contain neurotoxins that can damage the functioning of the nervous system (Liao et al., 2019). Some species, particularly those belonging to the Cubozoa group, such as the wasp jellyfish (*Chironex fleckeri*), are so dangerous that they can kill humans. However, most jellyfish species are harmless to people (Barnes, 1966; Cegolon et al., 2013).

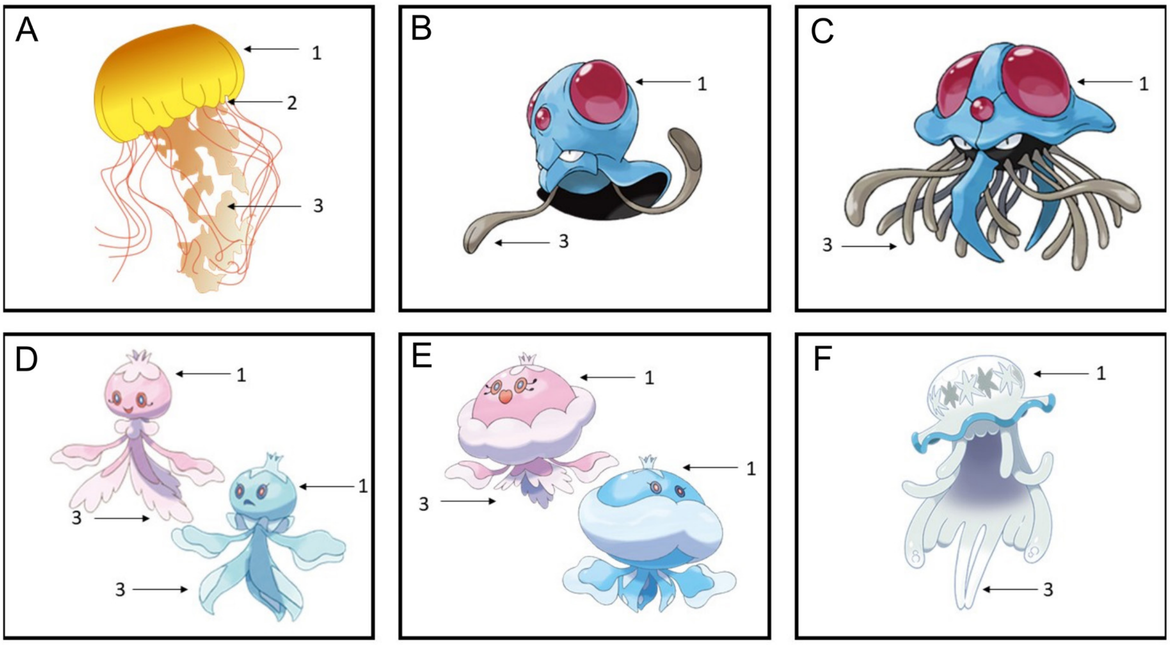

Figure 4. Jellyfish Pokémon. A. Scyphozoan jellyfish with some of its morphological characteristics. B. Tentacool. C. Tentacruel, D. Female and male Frillish. E. Female and male Jellicent. F. Nihilego. Structures: 1= umbrella, 2= margin, 3= oral arms. Pokémon designs are official artwork from the franchise (The Pokémon Company, 1996–2023).

CNIDARIAN CHARACTERISTICS THAT THE FRANCHISE COULD EXPLORE

The Pokémon species Remoraid (#223) and Mantine (#226) represent a mutualist interaction, as Mantine does not mind that Remoraid attaches to its fin to eat its leftovers (The Official Pokémon Website, 2023). On the other hand, Parasect (#47) is completely controlled by the fungus attached to its back (The Official Pokémon Website, 2023), showing an example of a parasitic interaction. Endocnidozoans could be an interesting addition to the Pokémon world, particularly Myxozoan parasites found in the brain of species like the mole *Talpa europaea* (Friedrich et al., 2000).

The abilities of Pokémon that resemble jellyfish are directed toward attack. In reality, the interaction of cnidarian venom and humans goes beyond sting poisoning and could be explored as potential drugs for parasitic and fungal diseases (Morales-Landa et al., 2007) and their compatibility for creating skin grafts (Fernández-Cervantes et al., 2020). This idea could be exploited in the franchise within Pokémon hospitals.

As mentioned above, the cnidarian life cycles are unique and could inspire the creation of new striking evolutionary lines. An example is the knotted thread hydroid (*Obelia geniculata*), where the larval stage (planula) generates a polyp. This polyp forms a colony (several individuals with different functions that work as an integrated organ-

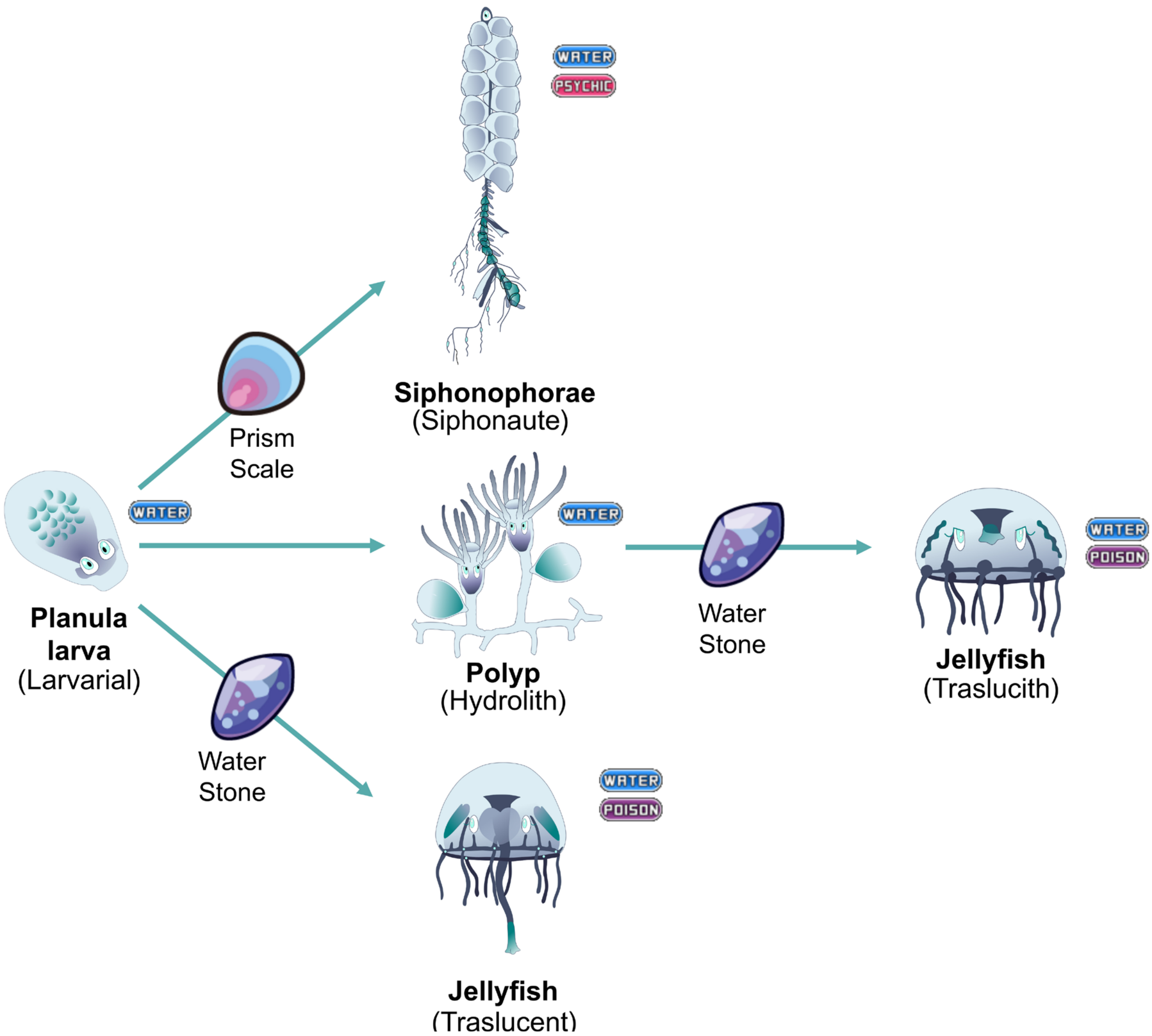

Figure 5. Proposed Pokémon designs based on the complex life cycles and phases of medusozoan cnidarians. Suggested character names are indicated in parentheses. The evolution items and Pokémon Type symbols are official artwork from the franchise (The Pokémon Company, 1996–2023).

ism) that can release jellyfish; then, each individual jellyfish reproduces sexually with another jellyfish, generating a larva, thus repeating the cycle (Slobodov & Marfenin, 2004). Other fascinating medusozoans that could be considered are siphonophores, colonial organisms composed of polypoid and medusoid forms (Mapstone, 2015).

Because we are fascinated by cnidarian life cycles and morphologies, we offer an example of how facts from real-world biology could be incorporated in the design of new Pokémon (Fig. 5): Larvarial, a Water-type Pokémon larval stage that evolves (by levelling up) into Water-type Hydrolith, the polyp representation. If Larvarial is exposed to a Water Stone, it evolves into the dual-type Water/Poison Translucent, a jellyfish, while a Prism Scale transforms it into the mesmerizing dual-type Water/Psychic Siphonaute, a siphonophore. Also, when Hydrolith is given a Water Stone, it evolves into the dual-type Water/Poison Traslucith, another jellyfish form.

CONCLUSIONS

Of the 13,300 cnidarian species known worldwide, there are similarities between structures such as the tentacles, the bell, the oral arms, and calcified branches of seven Pokémon (Corsola, Cursola, Tentacool, Tentacruel, Frillish, Jellicent, and Nihilego) and the real-world cnidarians. Nevertheless, there are still many different species of coral, endocnidozoans, and jellyfish waiting to be adapted to the Pokémon world.

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