International Journal of Humanities Social Sciences and Education (IJHSSE)
*Volume 10, Issue 5, May 2023, PP 36-43*
*ISSN 2349-0373 (Print) & ISSN 2349-0381 (Online)*
*https://doi.org/10.20431/2349-0381.1005005*
*www.arcjournals.org*

# Connecting Fossil Inclusions with Artistic Representations to Approach Scientific Questions

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**Abstract:** *The interaction and collaboration between artists and scientists have evolved over the years with relevant scientific and social implications. Fossils represent important evidence for evolution and relationship between different species and environment. In this context, paleoart refers to art pieces depicting prehistoric life according to scientific evidence or public perception. Paleoart-inspired pieces may represent fossils or imagined representations of living organisms and their ecosystems. In this context, this Commentary is not a paleoart investigation, but my perspective on how fossils may inspire or be related to artistic representations to address of scientific questions.*

**Keywords:** *Amber; Art; Fossil; Paleoart; Representations; Science*

## 1. Introduction to Paleoart

The interactions at different levels between art and science have been well documented as illustrated in these publications of my authorship [1-7]. One of these interactions is paleoart, which is considered to have originated in early 1800s in England [8]. Paleoart was defined by Ansón et al. [9] as any original artistic work that attempts to depict prehistoric life according to scientific evidence or public perception. Although paleoart was defined as being bound by scientific data involving biologically informed restoration to fill in missing data and relating to extinct organisms, ancient (pre-1800) proto-paleoart may include pieces that do not rigorously adhere to scientific evidence or may be inspired by ancient fossils [8]. Accordingly, paleoart-inspired pieces may represent fossil remains or imagined depictions of the living creatures and their ecosystems[10]. These pieces could include both vertebrate and invertebrate representations.

## 2. Paleozoic Era Biodiversity

Echinoderm paracrinoid, *Oklahomacystis tribachiatus*, from Oklahoma, USA (Figure 1A), and *Amecystis* sp. from Canada (Figure 1B) are fossils of the Ordovician period (Paleozoic era, 293 mya). A crinoid stem is also present on the plate (Figure 1B). The visual art piece illustrates the diversity of echinoderms in the Paleozoic era (Figure 1C).An interesting assemblage of fossils illustrates the biodiversity in the Devonian of Oklahoma, USA(Paleozoic era, 345-395 mya) (Figure 1D). Three different trilobites and a brachiopod are represented on this plate. A large cephalon of *Huntonia*, a trilobite with a strange cephalic process, an unidentified brachiopod, a complete enrolled *Paciphacops campbelli* and the "horns" of a *Dicranurus* trilobite. There is also another cephalon of *Paciphacops* and several other different brachiopods exposed on the large plate. The visual art piece recreates biodiversity and interactions between different organisms since ancient times (Figure 1E). Multiple crinoids are found in a plate from the Mississippian of Missouri, USA (Paleozoic era, Carboniferous Mississippian period, 320 - 345 mya) (Figure 1F). The *Uperocrinus pyriformis* crinoid on the left has a long, smooth-plated cup and a multi-plated tegmen. The *Macrocrinus konincki* in the center of the slab is an unusual came rate crinoid with very nodose plates. The ornate example of *Platycrinites* sp. is at the bottom of the plate. There is also a partial *Steganocrinus* and many crinoid stem fragments (*Actinocrinites* spp.-?) on the matrix block. The art pieces from different artists inspire the importance of the seabed on the habitat diversity (Figures 1G and 1H).

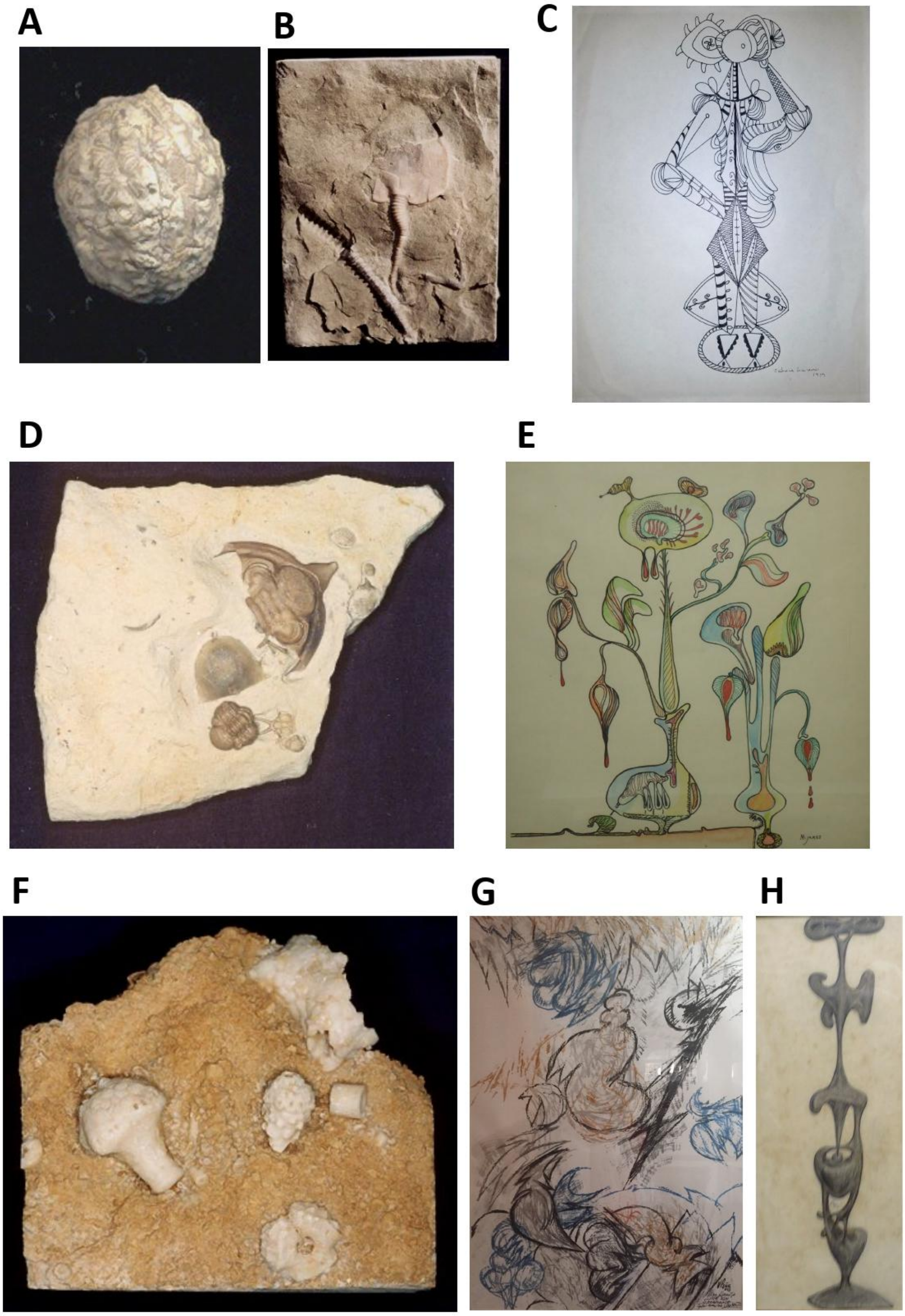

**Figure1.** ***Paleozoic era biodiversity.*** *(A-B) Echinoderms. (C) Servando Cabrera Moreno (Cuba, 1923 - 1981). No title, ink on paper, 1959, 34 x 25.5 cm. (D) The Devonian Sea. (E) José Mijares (Cuba, 1921-USA, 2004). No title, pencil on paper, ca. 1960, 40 x 40 cm. (F) The Carboniferous Sea bottom. (G) Umberto Peña (Cuba, 1937). No title, drawing on Guarro paper, 2013, 60 x 100 cm. (H) Agustín Cárdenas (Cuba, 1927 – 2001). No title, drawing on paper, ca. 1950s, 56 x 27 cm.*

## 3. PREDATORY BEHAVIORS

A fossil contains a fish scale from the Mesozoic era, Cretaceous period of Morocco (65-146 mya) (Figure 2A). The fish scale exhibits several puncture marks made by the sharp teeth of a hungry crocodile (*Crocodylus* sp.). A 3-dimensional crocodile tooth is still present in one of the holes with corrugated enamel reddish-brown coloration and exhibits only a slight amount of wear to the very tip.

This fossil illustrates predation of fishes, represented by a Green River fish fossil, Eocene, Cenozoic era, Wyoming, USA,65 mya (Figure 2B) by a ravenous crocodile represented in the art sculpture (Figure 2C). Bivalve predation in the Pliocene Sea (Pliocene period, Cenozoic era, 1.6 - 5 mya) is illustrated by a *Macrocallista nimbosa* fossil bivalve from the Pliocene of Florida (Figure 2D). One of the valves displays a small, perfectly round hole, presumably bored by a mysterious unidentified gastropod (*Warthenia* sp.-?, Pennsylvania, USA; Figure 2E). This predatory behavior of ancient gastropods can be interpreted from the cup and plate in Figure 2F. Trilobites such as *Elrathia kingi* (Utah, USA) in the Cambrian see (Paleozoic era, middle Cambrian period, 510-543 million years ago) were bitten by predators like *Anomalocaris*. Interestingly, some trilobites lived enough after the attack to grow and molt as seen in fossils where the pleuron grew a new border (Figure 2G). The visual art piece recreates fossil inclusions and remind an elegy for those trilobites that did not escape from predators (Figure 2H).

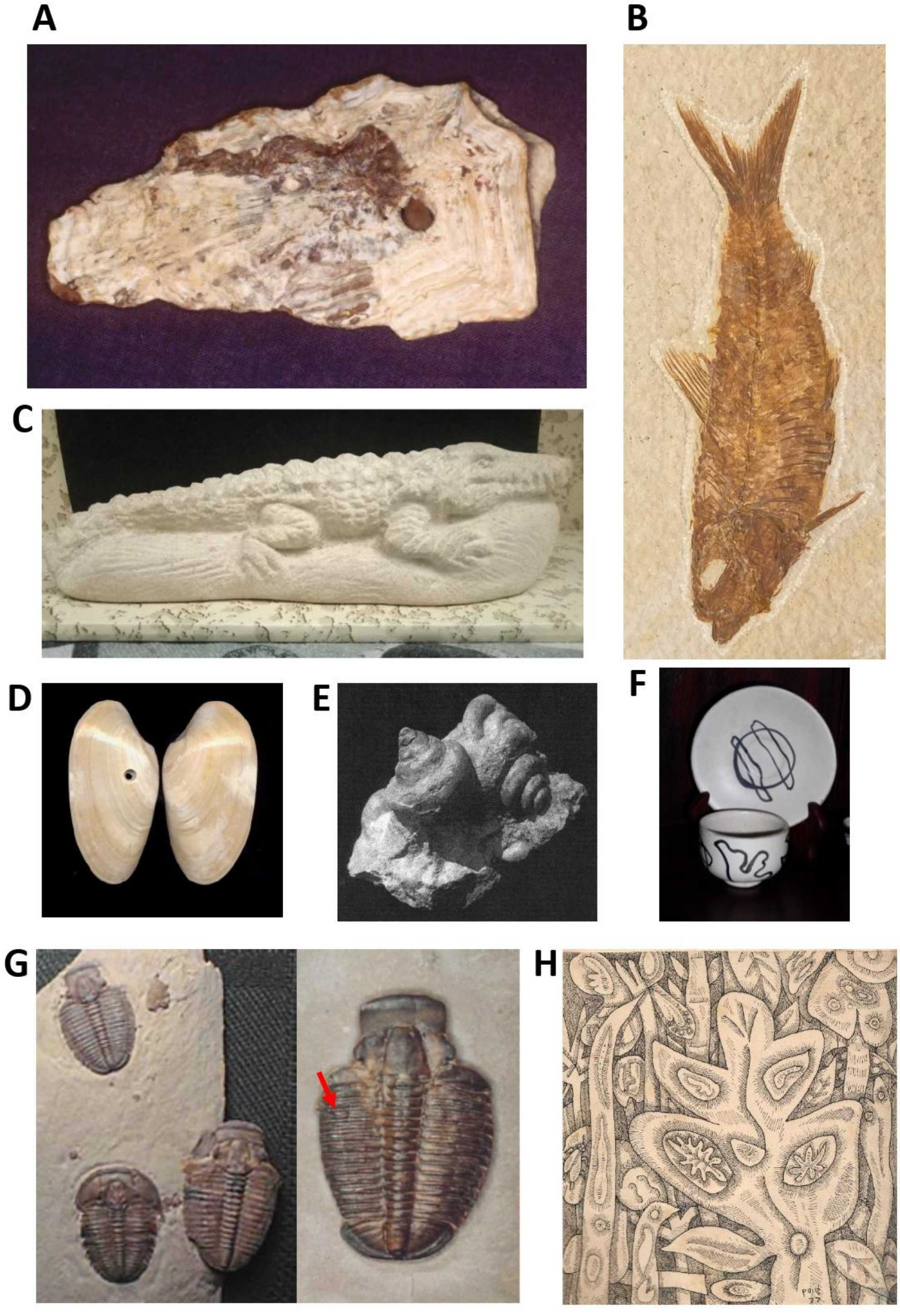

**Figure2.** ***Predatory behaviors.*** *(A) Fish scale from the Mesozoic era. (B) Green River fish fossil. (C) Angel Iñigo Blanco (Cuba, 1935 – 2014). Crocodile (Cocodrilo), limestone sculpture, 1998, 17 x 5 x 5 cm. (D) Predation of fossil bivalve. (E) Predator gastropod. (F) Amelia Peláez (Cuba, 1896-1968). Cup and plate, ceramic, 1960. (G) Trilobite predation and recovery. Red arrow points at pleuron with a new border. (H) Ernesto González Puig (Cuba, 1913-1988). Illustration for Elegy (Elegías) of Nicolás Guillén, ink on paper, 1977, 25 x 25 cm.*

## 4. THE AMBER ZOO

Many species are well preserved in amber. For example, a Caribbean amber piece from Dominican Republic(Cenozoic era, Oligocene period, 24.5 – 38 mya) contains mite, spider, fly, grasshopper, springtail, beetle, unidentified insects and plant seed fossils (Figure 3A). Other species including ticks [11], mites and *Micetophilidae* are found in Dominican amber (Cenozoic era, Miocene period, 24.5 mya) (Figures 3B and 3C).Findings in Dominican amber have suggested transmission of avian malaria by mosquitoes in the upper Eocene [12, 13]. Amber is also a material used in art for multiple representations worldwide (Figure 3D-3G).

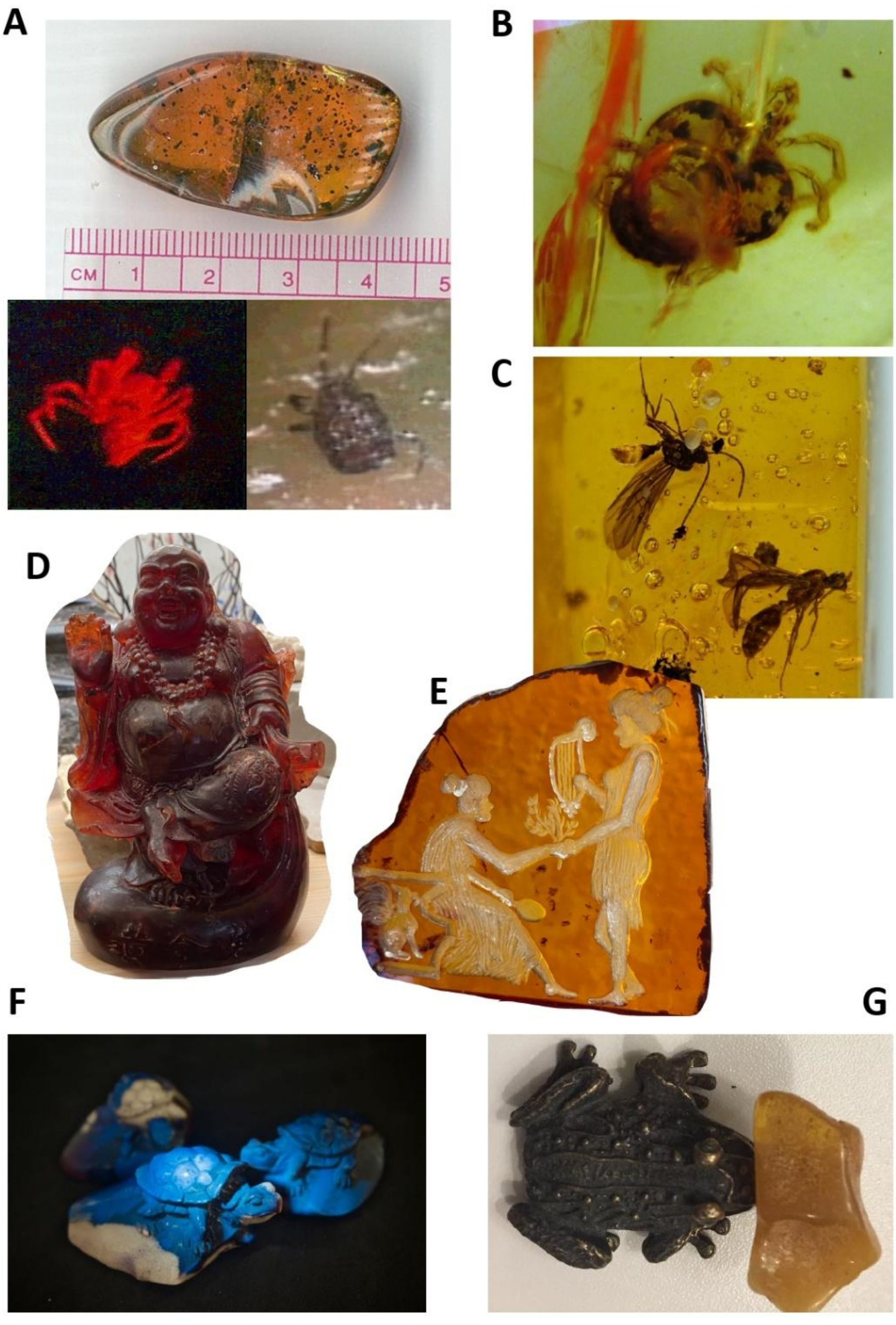


**Figure3.** ***The amber zoo.*** *(A-C) Dominicam amber with multiple inclusions. (D) Carved Buddha on Burmese amber. (E) Carved scene on Burmese amber. (F) Carved turtles on amber from Bali, Indonesia. (G) Baltic amber from Lithuania.*

## 5. TREE OF LIFE: MORE ART FOR INSPIRATION OF SCIENTIFIC QUESTIONS

Based on fossils of the KGJ Collection (Ciudad Real, Spain), a tree of life was constructed with several species in different environments (Figures 4A-4M). Then, I went through the art collection and selected 12 pieces (Table 1) that motivated questions in paleoart, paleobiology and paleontology. Then, a network analysis between art and fossil pieces was conducted to identify questions and research directions such as (a) characterization of biodiversity evolution over time and which factors affected its evolution, (b) integration of fossil data on phylogenetic analyses, (c) evolution of species interactions, (d) better comprehension of catastrophic selection processes across evolution**,** and (e) paleoproteomics for developing proteomics approaches for the analysis of inclusions in fossil amber considering that proteins may be better preserved than nucleic acids (Figure 5).

**Figure4.** ***Tree of life.*** *On the sky: (A) Bird feather (Utah, USA, Eocene, Cenozoic era, 65 mya). (B) Mosquito (Eocene, Utah, USA, 54 mya). On the sea: (C) Shark tooth (Carcharocles megalodon, Neogene, Cuba, 2.58 – 23.03 mya). (D) Plesiosaur vertebra bone (Zarafasaura oceanis, Morocco, Cretaceous, 66.0 – 72.1 mya). (E) Lobster (extant Thalassina aff. emerii, Indonesia, Quaternary Pleistocene, 0.01 – 2.58 mya). (F) Fish (extinct Rhacolepis sp. from the Cretaceous Santana Formation of Brazil, 146 mya). (G) Scallop (Pecten sp.) and barnacles living together (Sarasota, Florida, USA, Pliocene period, Cenozoic era, 1.6 – 5 mya). (H) Dinosaur (Keichousauris hui, Mudstone and silts of Guizhou, China, Middle Triassic, 245 mya). On the field: (I) Beetle (Coleoptera, Jurassic, China, 208 mya). (J) Keaki tree leaf (Zelkova nervosa, Eocene of Utah, 54 mya). (K) Unidentified plant (Pliocene of Colorado, USA, 5 mya). (L) Dinosaur eggshell (Maiasaura peeblesorum, Cretaceous of Montana, USA, 146 mya). (M) Mammoth tooth (Mammuthus spp., Pleistocene, Nebraska, USA, 1.6 mya).*

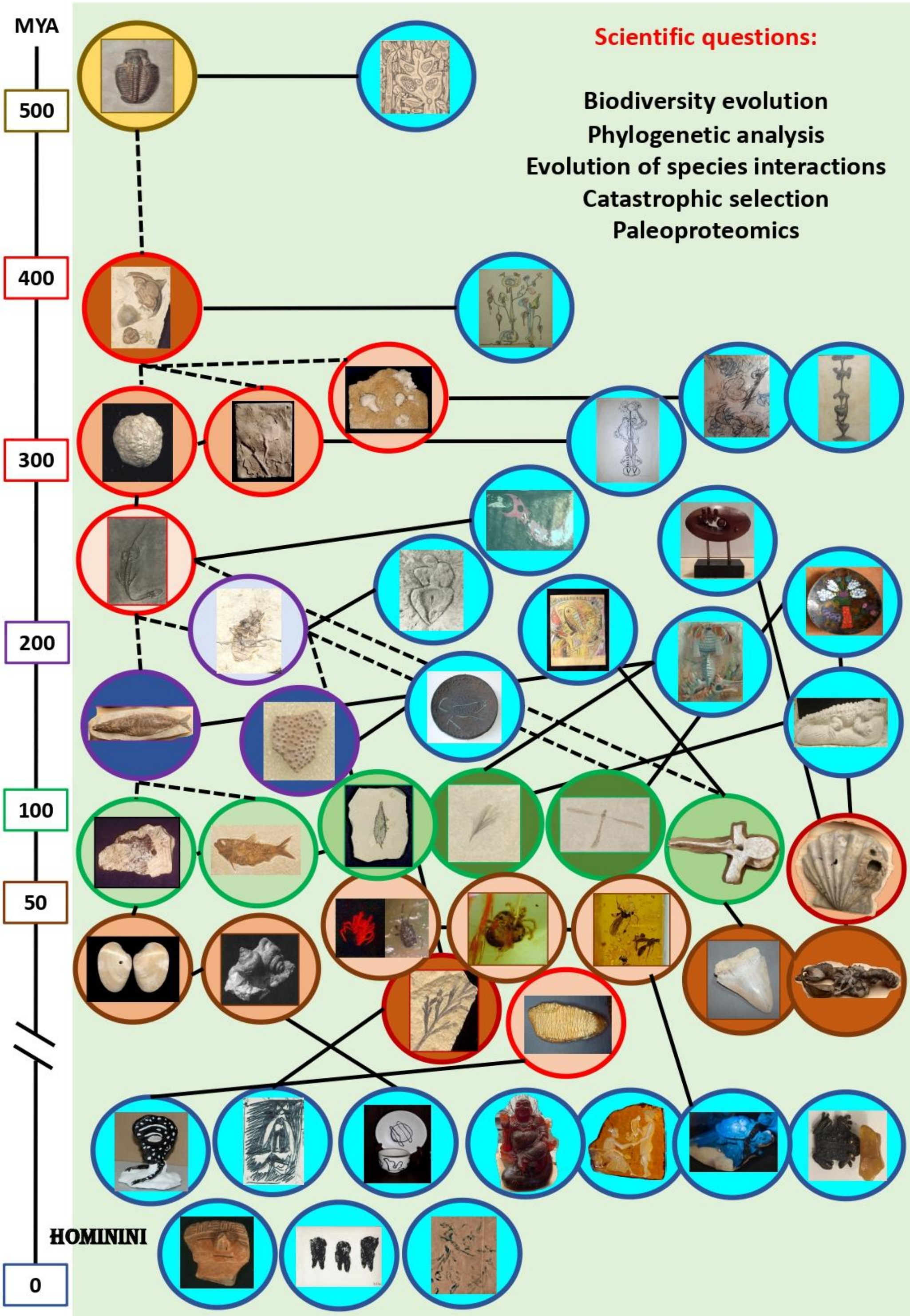


**Figure5.** *Network analysis of the interactions between art and fossils to address scientific questions. All fossils and art pieces of the study were included in the network analysis.*

## 6. Conclusions

This commentary is not intended to strictly fit into paleoart approaches but to provide author's view on the possible interactions between art and science through fossil inclusions to promote investigation and education. The collaboration between artists and scientists have evolved from inspiration, communication and instrumentation to other forms such as multi and trans disciplinary collaborations and research with a greater social impact[5, 14]. The scientific results caninspire artists and art can inspire scientists. The interaction between scientists and artists has served to address scientific challenges through innovative approaches in areas such as molecular biology, biotechnology and biomedicine [14]. In this context, the association of fossils with art pieces may contribute to a better understanding of complex paleontological and palaeobiological findings through inspiring new questions for scientists [15].

## Acknowledgments

Art pieces and fossil inclusions are courtesy of the KGJ Collection, Ciudad Real, Spain.

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**Citation:** *José de la Fuente. "Connecting Fossil Inclusions with Artistic Representations to Approach Scientific Questions" International Journal of Humanities Social Sciences and Education (IJHSSE), vol 10, no. 5, 2023, pp. 36-43. DOI:* https://doi.org/*10.20431/2349- 0381.1005005.*