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**Abstract:** When Napoléon Bonaparte invaded Egypt in 1798, he took with him a group of savants to study the natural history, architecture, ancient history and society of Egypt. One young naturalist, Etienne Geoffroy Saint-Hilaire, went along and made his mark in the study of living and mummified animals, setting the course for his future successes and fame when he returned to Paris in 1801. But during his time in Egypt, when he was free to roam physically and intellectually, he formulated a radical, all-encompassing theory, which he claimed could explain all natural forces and processes in the world.
When Napoléon Bonaparte invaded Egypt in 1798, he took with him a group of savants to study the natural history, architecture, ancient history and society of Egypt. One young naturalist, Etienne Geoffroy Saint-Hilaire, went along and made his mark in the study of living and mummified animals, setting the course for his future successes and fame when he returned to Paris in 1801. But during his time in Egypt, when he was free to roam physically and intellectually, he formulated a radical, all-encompassing theory, which he claimed could explain all natural forces and processes in the world.

The vital principle

"Knowledge is so sweet, that I was able to put out of my mind that a bomb might explode at any moment and instantly hurl me and my evidence into the abyss". So recollected Etienne Geoffroy Saint-Hilaire (1772-1844) of the last few weeks spent in Egypt in 1801, as part of the scientific and artistic commission that accompanied Napoléon Bonaparte (1769-1821) and his army during their ill-fated invasion.

Geoffroy had, along with more than 100 other 'savants', spent almost four grueling years living in conditions ranging from luxurious to squalid, traipsing over scorching deserts wracked with thirst, dodging the swords and canons of the Mamelukes – the dreaded warrior tribe then ruling Egypt – attempting to avoid the ravages of the plague and being besieged by the Turks and British. He looked back on his Egyptian experience with a mixture of horror and nostalgia.

Incredibly, Geoffroy carved out the time to study a diversity of natural history subjects of Egypt. He was acutely aware he had to establish his scientific credentials on the expedition and took every opportunity to observe, think and develop his ideas. His industry paid off. On his return to Paris, Geoffroy’s ideas propelled him to prominence at the new Museum of Natural History. Most notably, his ‘unity of plan’ or ‘unity of composition’ effectively established the concept of evolutionary homologues (or, as he called them, “analogues”). Nevertheless, Geoffroy came close to inviting ridicule from his colleagues for a less well-known idea that he hoped would bring him fame and academic fortune.

It was his “theory of everything”. This could explain “all galvanic, electric and magnetic phenomena, the nervous fluid, germination, development, nutrition, generation, necessary for all organs,” he claimed in 1801 in a letter to George Cuvier (1769-1832), then professor of comparative anatomy at
the Museum of Natural History back in Paris. “I can be more precise,” Geoffroy went on. “I can explain the intellectual function by physics.”

However, for fear of ridicule, ostracism and the effect it would have on his career, he abandoned this all-encompassing idea. Geoffroy did not publish any of the several manuscripts he had written on his “vital principle” and pursued the safer, more plausible concept of analogues. But how did a 24-year-old ‘subcurator and sub-demonstrator’ in zoology at the Cabinet of Natural History at the Jardin des Plantes (later the Museum of Natural History) in Paris, come to be trotting alongside Bonaparte in Egypt? What, exactly, was his theory of everything? And how did he come upon it?

The Egyptian campaign

In 1798, Bonaparte managed to convince the Directorate – the ruling body in post-revolutionary France – to fund one of the most ambitious military campaigns of its time. Fresh from his successes in Italy, and with France still smoldering from defeats by the British in India, Bonaparte argued that a military invasion of Egypt would serve several purposes: it would open up a potential route to India, permitting a more promising assault on the British grasp on the country’s commerce; it would also free the Egyptian people from the dominion of the Mamelukes, a fierce and reputedly invincible warrior-tribe, who had effectively ruled the Egyptians for 550 years.

In fact, an invasion of Egypt had been mooted for many years since it would act as an insurance policy against the loss of France's American colonies. The Directorate also realised that there was nothing more dangerous than an idle, recently victorious and ambitious general. A campaign that kept Bonaparte – and his army – busy thousands of miles away meant that neither could pose a threat at home and might even be useful in France's colonial ambitions.

But Bonaparte was a man of vision, not least when it came to his own image. He knew that military success, whilst glorious and a means to more fame and power, was transitory. The arts and sciences, however, are immortal. So, having being given the go-ahead in March 1798, Bonaparte sought the advice of chemist Claude-Louis Berthollet (1748-1822) and invited around 150 scientists, artists, engineers and surgeons – known as the savants – to accompany him to Egypt. This was a significantly enhanced version of the Commission of Science and the Arts, which had accompanied him to Italy several years earlier. The ‘Institute d'Egypte’, as it became known, ran along similar lines to the Institute de France, with Gaspard Monge (1746-1818) as president and Bonaparte as vice president (Figure 1).
There were some big names in the philosophical entourage, including Berthollet and Monge, the mathematician Jean-Baptiste Joseph Fourier (1768-1830), the mineralogist Déodat-Guy-Sylvain-Tancrède Gratet de Dolomieu (1750-1801) from whom we get Dolomite, and the amazingly inventive engineer/physicist Nicolas-Jacques Conté (1755-1805), who is immortalised in the type of crayon used by artists world-wide. It was Conté who fixed all manner of devices needed by the military and who, when there were no tools in existence to fix particular devices, made the tools to make the tools to fix them.

Bonaparte’s orders were to capture Malta and Egypt, attempt to remove the British from the Orient, build – or at least begin the process of building - a canal through the Isthmus of Suez, improve the situation of the locals and keep the Turks happy. The expedition, including the immensely competent generals Kléber and Desaix, numbered 400 ships and an army of almost 35,000 men (none of whom knew their ultimate destination), which set out from Toulon, Marseilles, Genoa, Ajaccio and Civita Vecchia to rendezvous at Malta in May 1798, just ten weeks after the approval of the campaign’. After a ‘siege’ of one day and the loss of only three French soldiers, the great Knights Hospitaller of St. John of Jerusalem (Knights of Malta), who had originally formed during the crusades of the 1100s and who had a history of resolute courage, capitulated and Malta was Bonaparte’s. He spent six frantic days putting the Maltese administration in order before sailing for Alexandria.

Unbeknownst to Bonaparte, Admiral Nelson (1758-1805) had been sent to search out and destroy the French fleet. He found it eventually at Abukir Bay, where he cut off Bonaparte’s escape route. This set the tone for the campaign, which ultimately ended in humiliating defeat at the hands of the Turks and British. There were memorable victories for the French, such as the Battle of the Pyramids, but in the end, Bonaparte realised Egypt would never fulfill his ambitions and that he needed to pursue his political objectives back in France (Figure 2). He departed from Egypt in August 1799, leaving behind thousands of disgruntled soldiers, irate generals and disillusioned savants, most of whom would not see France for another two years. But Bonaparte’s resilience is the stuff of legend and he soon became First Consul and eventually Emperor. He was not the sort to let a minor Egyptian glitch disrupt his smooth journey to absolute power.

**Commission of Science and Arts**

It is hard to think of a similar military campaign that has been so scientifically bold. Even disregarding the eminent scientists, engineers and artists who comprised the learned group, the formation of a scientific institute in a foreign land, the collection and detailing of every aspect of current and ancient life there and the (at least attempted) removal of a large number of artefacts – including the Rosetta stone – for study back in France, was a feat of unparalleled brilliance.
Many of the scientists and artists who comprised the Commission of Science and Arts were technicians, rather than scientists and artists, _per se_. Only about one third could truly be called savants, but their enthusiasm and productivity belied this. The Institute d’Égypte was formed from members of the Commission, and sat for the first time on 6 Fructidor an VI (23 August 1798). Two sections – mathematics and physics – comprised 26 savants, with the rest belonging to ‘Political Economy’ and ‘Arts and Letters’. The institute held 62 meetings while in Egypt, the last one on 1 Germinal an IX (22 March 1801).

Those participating read or submitted written papers to the different sections, and the military at times called on members of the Institute for advice. While in Egypt, the Commission set up a printing press, and the Institute published the _Courier de l’Égypte_, which described public events, and _La Décade Égyptienne_, which was modeled on _La Décade Philosophique_, the journal of enlightened learning in France, which published more academic works. _La Décade Égyptienne_ was also published in four volumes in Paris between 1799 and 1802. As well as contributing to this specialised journal, savants published papers in other, established scientific journals. The surgeon, René-Nicolas Desgenettes, published a book in 1802 entitled _Histoire Médicale de l’Armée d’Orient_ and the artist Vivant Denon published his _Voyage dans la Basse et la Haute Égypte_ also in 1802. Two of the more famous scientific works emanating from the Egyptian campaign were Monge’s paper on mirages, which he read before the Institute’s second meeting, and Berthollet’s _Observations sur le natron_ (hydrated sodium carbonate), which was one of the many investigations he undertook during his time in Egypt. But the most ambitious work, published in France between 1809 and 1828, was the monumental _Description de l’Égypte_. This had clear sections on antiquities, the modern state and natural history and included an atlas of maps. Fourier wrote the preface, there were ten albums of plates, three atlases and nine volumes of text.

Etienne Geoffroy Saint-Hilaire’s natural history studies formed a large and significant part of this immense body of work, although the work of others on mineralogy and botany were well represented. Together with Jules-César Lelorgne de Savigny (1777-1851), and assisted by Alexandre Gerard, Geoffroy produced much of the zoological work: Geoffroy did the ichthyology, Savigny the ornithology and all the invertebrate work, with mammals and reptiles being shared between the two. Geoffroy’s son, Isidore (1805-1861), contributed text, which accompanied his father’s work. Whilst Savigny was known for the meticulousness of his research and his relentless supervision of engraving of plates for the _Description_, Geoffroy was less exact, and the results are, therefore, less satisfying overall.

But in Egypt, Geoffroy showed no lack of enthusiasm. Early on, he visited scholars, fishermen, felhadin (the working class), snake charmers and artisans. He went on numerous expeditions, including the second one to upper Egypt, where he investigated caves, ruins, excavations and tombs of the ancient Egyptians and took an intense interest in mummified animals. He drew, dissected and mounted hundreds of specimens. But it was between November 1800 and March 1801 that he was his most productive, giving lectures to the Institute on no less than eight subjects. It was, it seems, also the time when he began to formulate his ideas on the ‘unity of plan’ and to speculate on the existence of a ‘vital principle’.
Geoffroy’s theory of everything

Writing many years later, Geoffroy recollected that during the siege in Alexandria, he was so consumed by his natural history studies that he was able to shut out the war raging outside. He was entirely distracted “…from the brouhaha of the siege…the throwing of bombs, and the nearby fires and the surprises of the besiegers and the plaintive cries of victims succumbing in the fight.”

Geoffroy, it seems, was thriving in this novel environment away from the influence of some of his more stifling peersxvi. In his letter to Cuvier dated 19 December 1801, Geoffroy laid out his thesis for the first time while in quarantine in Marseille xiii. It rested on the idea that light was the source of all natural phenomena: from sunlight, all bodies (corps) were generated and all natural processes derived.

Strange as this may sound, philosophers had long invoked light as the source of all life and matter. For example, Archdeacon of Leicester, Robert Grosseteste (1168-1253) hypothesized in his De Luce that light was the “first form of corporeity, and from it all else followed”xv. Isaac Newton (1642-1727) also envisaged light and its colours as small particles emanating from ‘shiny substances’ that were attracted and repulsed in the same manner as other small bodies. Geoffroy was, therefore, standing squarely on the shoulders of giantsxvi.

For Geoffroy, light was comprised of oxygen and heat (calorique) and heat itself made up of seven elements (principes) distinguished from each other by differences in density and their affinity for oxygen and corresponding to the colours of the rainbowxvi. If two streams of this vital fluid encountered each other, they would be attracted in Newtonian fashion, lose their elasticity and produce carbon, he argued. Combustion reversed this process, releasing the elements once more. This, Geoffroy believed, could explain phenomena as diverse as muscular contraction, germination or fertilisation, as well as electrical and magnetic processes.

Geoffroy’s discovery and dissection of electric fish from the River Nile – the Mediterranean torpedo and a catfish, Malapterus electricus (Figure 3) – were major influences on the development of this grand theory. “I was under the impression and, I might add, under the spell of the electric scenes in which I experimented,” he wrote.

I was in a fever of work which occupied me for three weeks until the day I embarked. I could only snatch an hour or two at the most to sleep during the
24 hours of each day. It was a crisis which had its phases of exaltation before which the great satisfactions of the spirit had not preserved the body from humiliation and exhaustion; my character changed and I was in imminent danger…The phenomenal manifestations of my two fish had led me to go beyond the circle of their considerations, to conclude from them in favour of nervous actions, and from these facts of animality, all the phenomenal productions of the material world.xxii

Electric fishes use specialized nerve cells and muscles to create electricity, sometimes strong enough to stun quite sizeable prey. In Geoffroy’s thinking, as in that of many others, electric fish united the phenomena of electricity, nerve action and muscular contractionxxxii. Indeed, electric fish had been a source of fascination to scientists and philosophers for thousands of years. Pliny, Galen and Scribonius amongst others, had written about them and pondered the nature of their emanations. Even up to the 18th century, there was plenty of uncertainty and it took a series of experiments by an ex-East India Company employee, Member of Parliament and amateur scientist, John Walsh, some more by scientist extraordinaire Henry Cavendish and superb dissections and drawings by the surgeon John Hunter to convince most scientists that torpedo fish and eels did indeed produce electricityxxix. These investigations would provide the impetus for Galvani’s work and for Volta’s invention of the artificial electric organ or voltaic cellxxx.

Since the young Geoffroy was more a natural historian and mineralogist than a physiologist or physicist, his understanding of electricity, magnetism and other ‘occult’ forces was probably limited. But he would certainly have been aware of the broad nature of these rapidly changing ideas and appreciated their significance. Finding himself in the company of other savants knowledgeable in areas that were not his own can only have helped bring him up to speed. For example, Etienne-Louis Malus (1775-1812) – one of the Engineers and a member of the mathematical section – had an interest in the physical properties of lightxxi.

It is intriguing that Geoffroy first communicated his ideas about light after a bout of ophthalmiaxxii.

From the end of September 1800, my dear Cuvier, since I wrote to you, I have been hit by ophthalmia of great stubbornness, for four successive periods and which lasted 29 days, during which I was totally blind. My eyes at this time were very sensitive and I was unable to read or go outside.xxxii

Unable to see for an entire month, his thoughts would have ranged freely without the distractions that sightedness brings. The darkness would perhaps have brought into sharp focus the significance
of light, its properties and actions. There is nothing from his letters at the time that mentions his grand theory involving light, but it was presumably fermenting in his mind, perhaps waiting for the desperation of the siege at Alexandria, the period of intense activity at that time and especially the catalytic effect of the collection of electric fishes, to provide him with the opportunity to finally put the pieces of the puzzle together.

**Abandoning the theory**

Geoffroy’s vital principle epitomized his quest for unity in nature, best illustrated by his concept of ‘unity of plan’. Both ideas involved a single ‘source’ for the generation of the diversity of forces, processes or forms that we see in nature. In the first case, the source was light; in the second, descendents were derived from an ancestral form. Moreover, in formulating these ideas, Geoffroy essentially theorized that physical forces and chemical processes on the one hand and biological entities (or at least animals) on the other, are all variations on a single theme. The ‘unity of plan’ idea, one that he did pursue, proposed that all vertebrates - and later invertebrates - were essentially built to the same body plan. Along with the ideas of Jean-Baptiste Lamarck, Erasmus Darwin and many others, this laid the foundations upon which Charles Darwin built his own theory of evolution.

Geoffroy did not pursue his grand theory, beyond his letters to Cuvier, and never published his two manuscripts on the subject. His letters to Cuvier in the final days in Egypt and while in quarantine in Marseille capture his mental and physical fragility. Poor health in Cairo and Alexandria, brought on by pushing himself too hard in his scientific work and the deprivations of the siege, forced him to withdraw from his colleagues. Their criticism of his theory worried Geoffroy greatly. Fourier especially “…wanted to prove that it was nothing but silliness.”

Geoffroy was desperate to return to Paris and the Museum as a respected scientist rather than a fool. His letters throughout his time in Egypt bear witness to a man who yearned for the approval of his peers, as much as to his enthusiasm for natural history. And so he asked Cuvier, in the same letter in which he explained his theory, to “Keep, my dear friend, all this chatter to yourself: do not expose me to the ridicule should a big mountain beget only a mouse!” and not to broadcast his disagreements with Fourier in what were “…our petty provincial discussions.” It seems that he was not prepared to expose his radical Egyptian idea to Parisian scrutiny without first putting flesh on its bones. This never happened, as Geoffroy got back into life in France, worked up his voluminous natural history material and concentrated on the ‘unity of plan’. It was, as it turned out, probably just as well.
Acknowledgements

I would like to thank Ralph Humphries for giving up his time to translate some of Geoffroy’s letters from Egypt.

Figures

1. Institute d’Egypte.


3. Nile catfish from the Description de l’Egypte, the catalyst for his theory.


v Chandler (Chander, D.G. 1966. The Campaigns of Napoleon, Macmillan, New York) quotes 32,000, Gillispie 36,000 and Herold, including sailors, 55,000.

vi Much of this description of the workings and production of the Institute d’Egypte comes from two sources, indispensable to those interested in this remarkable period in the history of science: Herold, 1962 and Gillispie, 1989.

vii The calendar had been altered and restarted on 24 October 1793 because of the revolution. The French Revolutionary Calendar, which existed between 1793 and 1806, was the result of debate between a number of poets and mathematicians, one of which was Gaspard Monge. There were 12 months, each of 30 days, with a few days left over. Month names were the work of the poets, related to plants, animals and tools and were in rhyming groups of three.

viii Mémoire sur le phénomène d’optique connu sous le nom de mirage, published in La Décade Égyptienne 1 in 1799 and in the Mémoires sur l’Egypte in 1800.

ix Berthollet had realised that he was observing the reaction of sodium carbonate and calcium chloride, which produced calcium carbonate. His later work, Essai de Statique Chimique, published in 1803, dealt with chemical reactions and the effects of various environmental factors, and was to change how chemistry was done from then on.

x See Gillispie, 1989.


xii Rudwick compares this field experience to a religious pilgrimage and calls it ‘liminal’ or relating to ‘threshold’: “In this ‘liminal’ environment the initiate is temporarily detached from the familiar features and taken-for-granted assumptions of his everyday life. He is exposed to unfamiliar experiences which give access to a new and deeper understanding of the familiar world to which he later returns” pp. 149-150 in Rudwick, M.

xiii Appel, 1987, explains these ideas more fully, whilst two unpublished manuscripts detailing Geoffroy’s theory in his own words can be found in: “Du calorique considéré comme principe vital et de ses lois de circulation dans le corps organisés” and “Ma physique ou système d’idées sur le fluide nerveux et subsidiairement sur les éléments réels des corps”, MS 2722, III and MS2722, I, Bibliothèque Central du Muséum National d’Histoire Naturelle.


 xv Later, Goethe, the empiricist, wanting to understand the nature of light through its manifestations and actions, was to realize that the most logical and productive route to this was also through the study of colour.


xvii Hamy, E.T. 1901, pp. XXI-XXII


xxi He discovered the principle of polarization of light and was awarded, in 1811, the Rumford Medal by the Royal Society of London.

xxii Ophthalmia is a generic term for eye inflammation which can result from exposure to sunlight and can be especially prevalent in regions where the incident sunlight is exacerbated by reflected sunlight from sand. This condition was common in soldiers and savants during the Egyptian campaign.

xxiii Hamy, 1901. p. 192.

xxiv He came out of retreat, however, to play a pivotal role in securing much of the scientific collections that the French had made during their time in Egypt, when the English threatened to confiscate the lot.

xxv Hamy, 1901. p. 216

xxvi Hamy, 1901. p. 217

xxvii Hamy, 1901. p. 220.