

ANATOMY AND GRAFTS – From Ancient Myths, to Modern Reality

ENXERTOS E ANATOMIA – Da Mitologia Antiga à Realidade Moderna

Bettencourt Pires M A., Casal D., Arrobas da Silva F., Ritto I C., Furtado I A.,
Pais D., Goyri O'Neill J E.

*Nova Medical School, Universidade Nova de Lisboa, Portuguese Anatomical Society,
(AAP/SAP), PORTUGAL*

FIG. 1 – CHIMERA, the modern icon of transplants – Chimera of Arezzo, Etruscan sculpture, c.380-360 BC – Archeological Museum, Florence
http://www.florence.museum.com/br/museu_arqueologico.php



ABSTRACT:

In medical terms, much is still to be learnt from ancient times' history. Such is certainly the case with the earliest historical signs of the concept of grafting and transplantations. Innumerable examples of zoo-anthropomorphic beasts and monsters, such as the Chimera, can be found throughout the world and in every culture, since the earliest times. In the Middle-Ages, we find several artistic representations of Cosmas and Damian, the patron saints of Medicine, transplanting the leg of a corpse in substitution of the amputated leg of a patient. Later, in the 16th Century, as we carefully analyzed the original text of Ambroise Paré's classification of prodigious living monsters and beasts, we detected what seems to be the first accurate scientific reference to the concept of regeneration of tissues after the first successful replantation and suture of the sectioned tendons of a human leg. In Leonardo da Vinci's biography, Vasari described that one of the first works of this extraordinary artist-scientist was the construction of an armored shield in which he built the representation of an imaginary frightening beast, that he constructed from different parts of the bodies of crawling insects and reptiles, collected in secrecy. In modern times, Mary Shelley's description of the monster Frankenstein is a clear allusion to the concept of grafting. These few selected historical examples seem to represent the constant scientific quest for the possibility of regeneration of tissues, inherent to grafting and transplantation that modern scientists are still in pursuit to perfect. **Keywords:** Anatomy, Grafts, History.

RESUMO:

O aprofundamento dos conhecimentos da História da Antiguidade muito pode ainda contribuir para o aperfeiçoamento técnico da Medicina Moderna. É esse, decerto, o caso das primeiras referências históricas aos conceitos de enxerto e transplantação. Um pouco por todo o mundo e em todas as culturas, é possível encontrar inúmeros exemplos de seres antropomórficos e monstros, como a Quimera. Na Idade Média, são várias as representações artísticas de Cosme e Damião, santos patronos da medicina, a realizar um transplante de perna de um cadáver em substituição da perna amputada de um doente. Mais tarde, no século XVI, a análise cuidada do texto original da classificação de “Prodigiosos monstros vivos e bestas” de Ambroise Paré, permite detectar aquela que pode ser considerada como a primeira referência científica coerente ao conceito de regeneração de tecidos, após um caso de sucesso de reimplantação e sutura dos tendões seccionados de uma perna humana. Vasari refere na biografia de Leonardo da Vinci, que uma das primeiras obras desse extraordinário artista-cientista foi a construção de um escudo com a representação de um assustador animal imaginário, construído com diferentes partes do corpo de insectos e répteis. Na era moderna, a descrição do monstro Frankenstein, por Mary Shelley, aparece como uma clara alusão ao conceito do sucesso de enxertos. Estes exemplos históricos parecem significar que, desde os primórdios dos tempos, sempre existiu uma permanente busca científica da possibilidade de regeneração de tecidos, através de enxertos e transplantes, que na medicina moderna continuam em vias de aperfeiçoamento.

Palavras-chave: Anatomia, Enxertos, História.

***“Je le soignait,
Dieu le guérit.”***
(Ambroise Paré, 1585)



INTRODUCTION

Much is still to be learnt from ancient times' history whenever, with due respect, we research what the History of Medicine and History of Art still have to offer in terms of the advances of medical technology. Such is certainly the case of the earliest mentions to the concept of grafting and transplantation.

Galen stated, in 200 AD, *On His Own Books*¹ [1], that Sciences and Humanities should not be studied independently. To-day, these statements remain an absolute truth, and modern physicians should thrive to perfection, not only through the

constant update of the innumerable technological advances, but also through the meticulous knowledge of the many historical facts and “hidden treasures”, offered by History in help of the resolution of the paradoxes of modern technology.

In this sense, we researched the important contributions of ancient mythology and History of Art, regarding the modern concept of grafting and transplantation.

In many circumstances, one cannot help feeling astonished at the precocious abundance of the earliest ideological signs of the concepts of grafts, implants and transplants, since the most remote stages of the history of Humanity.

As our researches progress, in the field of the history of transplants and grafts, it becomes clear that the concept of grafting between different

¹ “Most of those who want to study Medicine and Philosophy, and learn how to read texts correctly, will find, without previous thought, the books of those who taught both Sciences, the two greatest and most beautiful of Human Sciences.” Galen, “*Sur mes Propres Livres*”, in GALLIEN, *Epitome en Quatre Parties*. 1962, Union Latine d'éditions, Paris.

species was strongly prevalent in the minds of primitive cultures. The expression of fantasy in literature and arts demonstrates that, even though the concept of medical grafting is relatively recent (acquired in the 20th century), the idea of adding and substituting different parts of bodies between animal species is as old as the history of humanity [2].

THE CONCEPT OF GRAFTING IN ANCIENT MITHOLOGY

Primitive societies worshiped gods that were represented as animals. We can still find primitive cave paintings, illustrating bison, horses, bears, and deer, as central figures of hunting rituals, presumably as a form of recognition to these sacred

animals that were believed to represent a powerful source of vital energy to those that ate them [3].

The oldest surgery recorded in humans of the prehistoric archaeological records from the Bronze Age showed skulls being subjected to trephination: To relieve intracranial pressure, a circular disc of bone was removed from the calvaria and later replaced as an orthoptic autograft [4].

With the birth of the first civilizations, **in Egypt and Mesopotamia**, we discover artistic representations of zoo-anthropomorphic (half-animal, half-human) divinities of the early mythologies, such as the various zoomorphic divinities widely depicted in Egyptian art. (Fig. 2)[5] [6] [7]



Fig. 2 – Egyptian anthropomorphic divinities:

2a- Sculpture of *hieracocephalus* Horus, Musée du Louvre, Paris;

2b- *Ramesses between Horus and Anubis*, fresco painting from the tomb of Ramesses I in the Valley of Kings (KV16), Egypt, c.1280BC; [5] [6]

Fig. 2c – The Lamassu from Khorsabad (c.720 BC), Limestone, Musée du Louvre, Paris. [6] These huge carvings of human-headed winged bulls, called “Lamassu”, or guardian spirits of the gate, believed to ward off evil spirits, guarded each of the entrances through which foreigners were obliged to pass on their way to the throne room. Similar Lamassu kept stony watch over the entrances of other palaces, such as that of Ashurmasirpal II.

Nowadays, in museums, all over the World, we can find reliques of ancient Egyptian art, depicting the first pharaohs, and their divinities, such as the ibis-headed *Thot*, the god of scriptures; the cow-horned *Hathor*, goddess of female fertility and child-birth; the lamb-headed *Khnum* and *Harsaphs*; or the crocodile-headed *Sobek* [5].

Anubis, the divinity of the embalming, bore the head of a jackal. (Fig.2b)

Horus, the divinity of heavens and King of Pharaohs, was represented with the head of a hawk, or falcon. (Fig.2a, 2b) According to the Egyptian legend, Horus suffered the loss of an

eye in the combat against *Seth*, the horrific god of violence, hatred and envy. In a clear allusion to the possibility of regeneration of tissues after grafting, Horus recovered his eyesight after substituting the lost eye with the amulet of a serpent. From then on, Horus (and the Greek *Zeus*) would be represented with two different eyes, one in the form of the moon, the other of the sun.

In fact, in clinical terms, the first attempts to reconstruct body parts with local flaps date back

to c. 3000 BC, as recorded by the *Edwin Smith papyrus*². [8]

In **Mesopotamia**, the *LAMASSU* giant statues (Fig. 2c) [6], representing winged genie, built at the entrance of the palace of Khorsabad (c. 720 BC) can be visited at the *Musée du Louvre*; or from the Palace of Ashurmasirpal II, in the neo-assyrian period (883-859 BC), to be visited at the *Metropolitan Museum of Art*. These winged beings appear to be protective spirits and generally flanked images of the Assyrian king performing rituals. [9]

Several other anthropomorphic beasts are depicted in an interesting cylinder seal impression, from Ur, Iraq, (c.2700 BC), kept at the Oriental Institute of the University of Chicago. [10]

Greek mythology offers several anecdotes that immediately remind us how the Greek philosophers and medical practitioners had, in parallel with accuracy of anatomical knowledge, the

intrinsic concept of the possibility of grafting and transplanting [11-12-13]. Many of the heroes of the Pantheon were hybrids with zoo-anthropomorphic bodies. Greek tales introduce the strong fantasy of the concept of regeneration of the organic tissues of these hybrid divinities:

The Greek titan *Typhoeus (Typhon)*, (identified with the Egyptian *Seth*), was half-dragon above the waist, and half-man, from the waist down. It had 100 heads, feathers covering his back, and a tail covered with snakes. Zeus attacked him with lightnings, to cut his nerves. Hermes and Pan came to rescue, and re-implanted his nerves.

Typhoeus and *Echidna*, half-woman, half-cobra, bore several monstrous offsprings, most of which also were hybrids:

- *Cerberus* - the three-headed dog, guards the entrance to Hades, indefinitely fought by *Heracles (Hercules)* in the latest of his renowned twelve labours;
- *Gorgon* - the immortal snake-haired humanoid was created in its mother's image. Its stare could turn a person to stone;

² [<http://archive.nlm.nih.gov/proj/tp/flash/smith/smith.html>]

- *Hydra* - the nine-headed serpent, grew two new heads for every one that was cut off;
- And the *Sphinx* - the half-human, half-lion, forces those that it meets to answer its riddles, or die³. (Fig. 3a) [14]
- As many of the references to *Echidna*'s monstrous children immediately remind us of the concept of the regeneration of grafts, the monstrous fire-breathing *Chimaera*, considered by Hesiod⁴ as one of *Echidna*'s offsprings, has become the modern icon of transplantation. (Fig. 1) [14]

Etruscan and early Roman art resumes some of the Greek mythological hybrid beasts, such as *Typhon* (Typhoeus), the *Centaur* (Fig. 3b) [14] or the *Chimera* (Fig. 1). From then on, mythological figures have been a recurrent theme in European and Western art and culture.

³ <http://www.greekmythology.com/>
<http://www.theoi.com/Bestiary.html>

⁴ Hesiod refers in the *Theogony* (pp. 319-329), after Homer's *Iliad*, that *Echidna* «...was the mother of the *Chimaera*, who breathed raging fire, a creature fearful, great, swift-footed and strong, who had three heads, one of a grim-eyed lion, in her hinder part, a dragon, and in her middle, a goat breathing forth a fearful blast of blazing fire...»

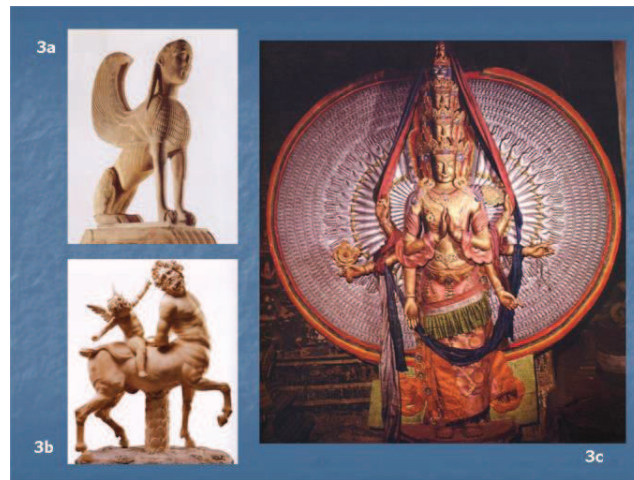


Fig. 3-

3a- The Naxian sphinx, Delphi, Greece, c. 540 BC. (Archaeological Museum of Delphi) [14]

This elegant representation of the Greek myth of the Sphinx reminds us of the many Egyptian sculptures of the sphinx that protected the entrance of the main Egyptian temples and tombs, such as the great Sphinx of Giza, protecting Khaefre; or the Sphinx of Amenhotep III.

3b- Centaur being ridden by Cupid. 1st – 2nd century AD. (Musée du Louvre, Paris). [14]

This Roman masterpiece recurs the mythological theme of the *bas-relief* of the South mesotope of the Greek Parthenon (440-438BC), depicting the Battle of the Lapix and the Centaurs.

3c- Sculpture of AVALOKITESHVARA, Himalayan Monastery of Tabo, Spiti (15th C.) According to M. Singh (1968), the thousand arms of Avalokiteshvara whirl up in a wheel in the form of a shell. The thousand eyes, placed in the palm of each hand, reflect the infinite mysteries of the divinity. [15]

recorded in the Edwin Smith papyrus and Sanskrit

Searching around the globe for other mythological

hybrids, one should not forget a short passage

through the fabulous **Hindu mythology**.

The central figure of *Avalotishkevara* (Fig. 3c) [15],

the Buddhist divinity that bears several heads and a

great number of arms and eyes, immediately

reminds us of Pearson's information, that the

earliest attempts to reconstruct body parts with local

flaps date back to approximately 3000 BC, as

texts from India[8]. Some of these flaps are still in

use today as the forehead flap for nasal

reconstruction described in India by *Sushruta* 600

BC. ⁵

The Hindu legend of *Ganesh* (the

elephant-headed divinity of fortune and

⁵

<http://ia700305.us.archive.org/1/items/englishtranslati00susruoft/englishtranslati00susruoft.pdf>

prosperity) immediately comes to the mind of those who search for signs of the concepts of grafting and transplants in ancient mythologies⁶.

Bosch's extraordinary fantasies in painting. (Fig. 4) [19]

THE EVOLUTION OF THE CONCEPT OF GRAFTING IN THE MIDDLE AGES

It seems that during the Middle Ages, progress in flap surgery was slow, particularly in Europe, due to prevailing mysticism and religious proselytism. However, even in this period, Emperor Justinian II allegedly underwent nasal reconstruction after being overthrown. After this procedure, he was able to regain power [8][12][16][17].

In contrast, in the Arab world, progress in flap surgery was registered under the influence of Indian culture by Islam conquerors [18].

Interestingly, in Art, we find innumerable new examples of hybrids, such as the griffins in many capitals of Romanic cathedrals, or Hieronymus

⁶ According to the Hindu legend, *Ganesh* was the offspring of *Shiva* and *Parvati*. After a long absence from home, *Shiva* failed to recognize his grown-up son, and cut his head off. As *Parvati* reminded him of the adolescent's identity, *Shiva* was so afflicted by this that he ran to collect the first living creature's head that he found, and implanted the head of an elephant in substitution of the boy's own head. <http://hinduism.about.com/od/lordganesha/a/ganesha.htm>



Fig. 4 – Hieronymus Bosch. *The Temptations of St. Anthony*. (c. 1510, Museu Nacional de Arte Antiga, Lisboa) (three details) [19]. This subject of the hybrid devils haunting St. Anthony, was resumed by several Renaissance artists, such as Schongauer (1490); Grünwald (c. 1515); Dürer (c. 1516); Bruegel (1526); and later on as a favourite subject of surrealist art, as with Max Ernst (1945), S. Dali (1946); Diego Rivera (1947); or Don McBurney (1994)

Cosmas and Damian, the Christian patron saints of Medicine, were twin brothers, born in Arabia, who lived in Egaea, Cilicia (Turkey), and became eminent for their skill in the science of medicine. Under *Diocletian*, their prominence rendered them marked objects of persecution. Being apprehended by order of *Lysias*, governor of Cilicia, they underwent various torments that led them to die in martyrdom, about the year 283 AD.⁷

According to the legend, their most famous miraculous exploit was the grafting of a leg from a recently deceased Ethiopian to replace a

patient's ulcerated or cancerous leg, and the subject of many paintings and illuminations, such as the one by J. Huguet (1415-92), found in Santa Maria of Egara in *Terrassa*, Barcelona, Spain. Several other representations of this miraculous cure contributed to the fame of these two martyr saints, such as the works by Matteo di Paccino (1350-75); by Fra Angelico (c.1438) (Fig.5a); by F. del Rincón (c. 1450-1517); or by Mestre de los Balbases (1495)⁸(Fig. 5b) [20]

⁷ http://www.catholic.org/saints/saint.php?saint_id=471

⁸ <http://www.liveinternet.ru/users/4168247/post281222888/>



Fig. 5 - SS. Cosmas and Damian graft the leg of an Ethiopian man onto the stump of deacon Justinian;

5a- Fra Angelico , c. 1438 [http://www.delou-chiquito.com/2011_10_01_archive.html] ; **5b-** Jaume Huguet (1415-92). Santa Maria of Egara in Terrassa, Barcelona, Spain

Fig.5c – Ambroise Paré’s curved surgical scalpels. (Illustration on page CCCIII of the 8th Book of Paré’s 10 Books of Surgery) - Notice the carving on the handles of the scalpels, with zoomorphic feminine figurines. [23]

5d – Ambroise Paré – Illustration to the chapter of the Sea Monsters, (from page MLXVI, of the 25th Book, *Des Monstres et Des Prodiges* -The Complete Works of Ambroise Paré de la Vale au Maine, 1585) [23]

THE RENAISSANCE TIMES

In **Leonardo da Vinci’s** biography, Vasari (1585) described [21]⁹ that one of the first works of

⁹ VASARI (1585) described in Leonardo’s Biography that: «...It is said that Ser Piero da Vinci was at his country villa when he was sought by one of his peasants, who had with his own hands made a small round shield from the wood of a fig tree, and who wanted Ser Piero to have it painted in Florence. And so he had it taken to Florence and, without saying anything else to Leonardo about who’s in was, he asked him to paint something on it. Leonardo [...] after having it covered with gesso and prepared it in his own manner, he began to think about what he could paint on it that would terrify anyone that encountered it, and produce the same effect as the head of the Medusa. Thus, for this purpose, Leonardo carried into a room, crawling reptiles, green lizards, crickets, butterflies, locusts, bats, and other strange species of this kind and, by adapting various parts of this multitude, he created a most horrible and frightening monster with poisonous breath that set the air on fire. And he depicted the monster emerging from a dark and broken rock, spewing forth poison from its open mouth, fire from his eyes, and smoke from his nostrils, so strangely that it seemed a monstrous and dreadful thing

this extraordinary artist-scientist was the construction of an armored shield in which he built the representation of an imaginary frightening beast, that he constructed from different parts of the bodies of crawling insects and reptiles, collected in secrecy. [21]

In 1506, Leonardo dedicated one of his studies to the battle of St. George against the dragon¹⁰.

indeed. [...]» (transcription from Bondanella’s translation of Giorgio Vasari’s *The Lives of the Artists* (1998) , pp. 288-289. [22]

¹⁰ Leonardo da Vinci *Studies of St. George and the Dragon* (Pen and ink, c.1506, Windsor Castle, Royal Library)

In the 16th century, we find the transition between the barber-surgeon and the scientific medical practice, in the figure of **Ambroise Paré**, considered as *the Father of Modern Surgery*, after the publication of his Medical Texts (Fig. 5c; 5d).

[23]

As we carefully analyzed the original text of Ambroise Paré's scientific description and classification of prodigious living monsters and beasts [24], we detected what seems to be the first accurate scientific reference to the concept of regeneration of tissues, after successful replantation and suture of the sectioned tendons of a human leg.

11

Not by mere chance, the scientific mind of Ambroise Paré included - amidst his comments and attempts to classify the collection of hybrid

monsters and “*Other Strange Things*” (Fig.8b) - an original medical description of the possibility of replantation of a leg, with regeneration of tendons and nerves, after the careful surgical suture of the wound. In fact, when we consider the great amount of pages that Paré used in his Medical Book to describe the treatment of wounds and amputations, it seems quite clear that this reference to the possibility of suture and tendons regeneration, by the inventor of artificial limbs, in a book dedicated to the description of hybrids and «other strange things», carries the weight of the first accurate scientific reference to the possibility of success of transplantation and grafting, as a possible treatment to limb amputations.¹²

¹² Ambroise Paré [1585 –(1964)] *Des Monstres, des Prodiges et des Voyages*. [24]

Chap. XVIII – «*DE PLUSIEURS AUTRES CHOSES ÉTRANGES: “[...] Étienne Tessier, maître barbier chirurgien demeurant à Orléans, homme de bien, et expérimenté en son art, m’a récité que, depuis peu de temps avait pansé et médicamenté Charles Veriguel, sergent demeurant à Orléans, d’une plaie qu’il avait reçue au jarret, partie droite, avec incision totale des deux tendons qui fléchissent le jarret ; et pour l’habiller, lui fit fléchir la jambe, en sorte qu’il cousit les deux tendons bout à bout l’un de l’autre, et la situa et traita si bien que la plaie fut consolidée, sans demeurer boiteux ; chose digne d’être bien notée au jeune chirurgien, afin que lorsqu’il lui viendra entre ses mains telle chose, il en fasse de semblable. [...] Et, pour conclusion, je dirai avec Hyppocrate (Père et auteur de la Médecine) qu’aux maladies il y a quelque chose de divin, dont l’homme ne saurait donner raison. »*

¹¹ Ambroise Paré [1585 –(1964)] *Des Monstres, des Prodiges et des Voyages*. [24]

In the «*Appendice au Livre des Monstres*», Paré quotes Plinius: “*DES MONSTRES MARINS: Il ne faut douter qu’ainsi qu’on voit plusieurs montres d’animaux de diverse façon sur la terre, ainsi qu’il en soit en la mer d’étrange sorte, desquels les uns sont hommes depuis la ceinture en haut, nommés Tritons, les autres femmes, nommées Sirènes, qui sont couvertes d’écailles – ainsi décrit Pline – sans toutefois que les raisons que nous avons alléguées par ci-devant, de la commixion et la mélange de semences, puisse servir à la naissance de tels monstres... »* (Fig.9b)

Throughout the Renaissance, and till today, many artistic movements have been dedicated to the illustration of ancient mythologies, including paintings, drawings and sculptures of hybrids. The lists would be endless, and for this purpose, we will only quote Piero di Cosimo's masterpiece on *Perseus and Andromeda*, c. 1513¹³

PRIMITIVE CULTURES

Zoo-anthropomorphic creatures are quite abundant in indigenous art and crafts, all over the World, still co-existing with modern occidental civilizations.

In 2006, we had the pleasure of visiting the recently renewed collection of indigenous art of the *Musée du Quai Branly*, in Paris¹⁴. The Musée exhibits numerous examples of hybrid, half-human, half-animal figures and masks, as those found by the Korrigan expeditions to New Guinea in 1934-1939, or the exhibit of African statuettes and sculptures brought from Gabon, Nigeria or Benin in

the late 19th century. Those immediately remind us of the timeless ubiquity of the notions of metamorphosis that lie in the heart of mythical beliefs and their artistic expressions, in every human culture.

From the Oceania¹⁵, and the Pacific regions of the Melanesia, Micronesia, or Polynesia, we find the astonishing crafts of the *Vanuatu* people, from the Malakula Island, originally inhabited by cannibals, who built the *Rampamp*, ancestral funerary effigies of high-graded men, from which the head skeleton was recovered at the time of death and prepared to build the funerary effigy.

The human skull is overmodeled with vegetable matter and painted with natural pigments. The body consists of a vegetable fiber paste, decorated with bark belt, breast ornaments, shells, spider webs, pigs' teeth, and any other imaginable variety of materials, to reproduce the human expression. The rest of the effigy of the human figurine is built with all the variety of vegetable fibers, including dried

¹³ http://www.virtualuffizi.com/uffizi1/Uffizi_Pictures.asp?Contatore=123
<http://ferrebeekeeper.wordpress.com/2010/06/17/perseus-rescuing-andromeda-by-piero-di-cosimo/>

¹⁴ [http://www.quaibrany.fr/fr/collections/promenades-a-la-carte/rites-funeraires.html?tx_fepromenadealacartet3_pi1\[uid\]=851](http://www.quaibrany.fr/fr/collections/promenades-a-la-carte/rites-funeraires.html?tx_fepromenadealacartet3_pi1[uid]=851)

¹⁵ <http://wamena-gallery.com/en/tribal-art/oceania/overmodeled-ancestor-skull-vanuatu~60~530.html>
(also: <http://www.tribalartbrokers.net/praisetribal/?p=519> ;
<http://www.flickr.com/photos/51293088@N05/8170144584/> or
<http://www.learner.org/courses/globalart/work/191/index.html>)

banana leaves, and the resulting human sculpture with the height of the dead corpse is used as a funerary mannequin to stand at the entrance of the deceased home.

GRAFTING AND TRANSPLANTS IN MODERN ART

One should not finish this short passage through the World of Art, without mention to what modern art (including the *Seventh Art*) has to offer to the subject of Grafts and Transplants.

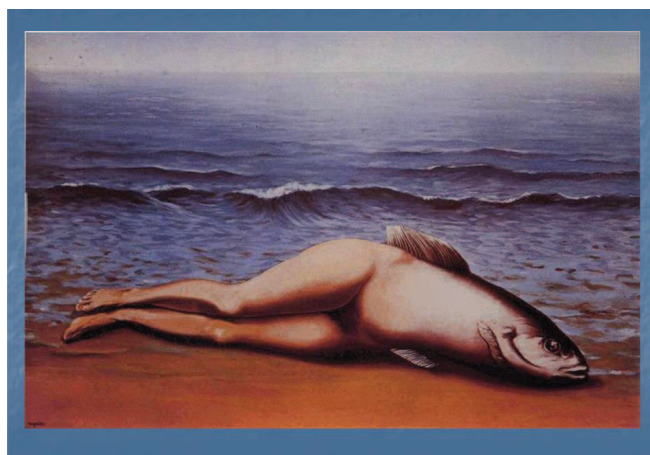


Fig. 6 - Magritte – *The Collective Invention*, 1934. <http://karlshuker.blogspot.pt/2011/03/rene-magritte-and-reverse-mermaid-very.html>

As if to help us add a note of conclusion to our nearly endless journey through the artistic illustrations of the concept of grafting and transplanting, the modern mind would immediately

Following the major scientific advances of the modern surgical techniques, the **Surrealists**, from the beginning of the 20th C. offered us some of the most inventive and picturesque illustrations of modernized hybrids. René Magritte's *Collective Invention*, twists our mind, depicting the «reverse mermaid» (Fig. 6), as a good example of how the human mind seems to have intrinsic ideas on the figures of grafting and hybrid transplants. Also, Salvatore Dali's work seems «haunted» by hybrid distorted images (Fig.15) [26].

«stump» on **Mary Shelley's** writings on *Frankenstein, or the Modern Prometheus* [27], followed by several cinematographic sequels that render the intrinsic concept of drafting and

transplanting, as a closer and nearer reality, when compared to the ancient myths that we have been reporting here.

As we contemplate images from the original Boris Karloff's construction of the lumbering, fearsome monster Frankenstein, in the Universal's 1931 adaptation of Shelley's Novel¹⁶, we clearly realize that in terms of grafting and transplantation, ancient myths are soon to become a better modern reality in Medicine and Surgery.

CONCLUDING REMARKS – THE STATE OF THE ART

Even as we write, some artist in the world will be sculpting, painting or fantasizing on hybrid zoo-anthropomorphic figure, as the theme seems to haunt the human mind since the beginning of times, in parallel with the constant scientific quest for the possibility of regeneration of tissues, inherent to grafting and transplantation. The few selected examples collected from the history of Art around the world, that we present here, seem to reflect the desire to reach for eternal life, even if only through

¹⁶ <http://uk.ign.com/articles/2012/11/01/the-top-25-horror-movie-villains> ; <http://youtu.be/-voWJkaRWtU>

the substitution of parts of the human body, with grafts and transplants that modern scientists are still in pursuit to perfect.

In modern dentistry, bovine bone xenografts are currently a well-accepted reality.^[28] A purified mineral matrix of bovine origin, mixed with the matrix of pig dental enamel is used as a substitute for bone tissue, produced by the chemical extraction of the organic matter of bovine bone, quite similar to the inner substance of human bones.
^[29]

Nowadays, **in plastic and reconstructive surgery**, autologous grafts and flaps are being performed routinely all over the world for reconstructing missing parts of the body, after burns, trauma, congenital defects, tumor extirpation, infections, gender reassignment surgery, and even for aesthetic purposes. However, this was not always the case, obviously.

Although the first description of skin grafting probably dates back to ancient Indian scrolls, current skin grafts were based of Barionio's work on skin flaps in sheep entitled "*On grafting in Animals*" in 1804. Skin grafts, albeit apparently

simpler to perform than skin flaps, were only put in routine clinical use after the description of partial skin grafting by Reverdin in 1869. [8] From then on numerous progresses and refinements have been made in graft surgery, encompassing not only skin, but also bone, tendon, fat, nerve, cartilage, and mucosa alone or in multiple combinations. [18]

In the **20th century**, especially after the World Wars, surgeons were faced with a massive number of injuries, many of which were rather complex. This spurred the development of numerous random and axial flaps.[8] Up to the present day, many of these flaps have been perfected, as a result of a better anatomical understanding. [30-35]

In parallel, Alexis Carrel's work on vascular anastomoses technique led to the development of free transfer of tissues, which granted him the first Nobel Prize earned by a surgeon in 1912. This seminal work allowed the development of replantation procedures. In fact, Alexis Carrel performed the first extremity replantation in a

complete amputated canine hind limb in 1906 [36-37].

This work paved the way to limb replantation [37-38]. The first arm replantation was performed in 1962 by Malt, the first hand replantation by Chen in 1963 and the first digital replantation in 1968 in Japan [39-41]. Since these early days this field grew exponentially, reaching an astounding degree of complexity. Presently, limb replantation is being performed routinely all over the world [39][42][43]. Moreover, replantations of increasingly mangled and distal amputations are being performed every day. [37]

Free flaps, in which a body part is transferred based on its vascular pedicle to a different place where there is a "defect", were first performed by Cobett in 1968. This surgeon transferred toes as free flaps to reconstruct missing digits in mangled or congenital malformed hands, rivaling ancient mythological musings [41][44-47]. In 1972, Taylor introduced a different concept of reconstructing vital parts of the body with redundant distant tissues, using the free groin flap.

From then on, almost every angiosome of the body has been transferred alone or in combination to reconstruct a previously unimaginable array of defects [41][44-47]. Some of these combinations are so strange as using the latissimus dorsi muscle flap to reconstruct the entire dorsal surface of the foot and most of the midfoot bones [48]. Oddly, many of these reconstructions have been crowned with pleasing results [48-49].

Recently, there has been a trend to associate the free transfer of nonvital organs from brain dead donors as free flaps with increasingly better immunosuppression protocols. [8] This has allowed the successful transference of the face, hand, forearm, arm, lower and upper leg, and even larynx and trachea from cadavers [8] [50-60]. In fact, skin xenografts and allografts, as well as synthetic skin

substitutes have been used regularly for the past decades in burn patients [61-66].

Finally, **in the last three decades**, different vascular territories have been associated with different distant tissues in order to create true living bioreactor to tailor make pre-fabricated flaps to reconstruct complex defects, namely those involving the airway, gastrointestinal, and airway tracts or those involving extensive injuries to the face or limbs [8] [51].

In this exciting new era in which almost everything seems possible, one cannot help noticing how much of what is now current reconstructive practice was inspired in the ancient myths and dreams of our predecessors.

BIBLIOGRAPHY

- [1] GALLIEN, "Sur mes Propres Livres" in *Epitome en Quatre Parties*. 1962, Union Latine d'éditions, Paris.
- [2] KUSS R; BOURGET P. (1992) *An Illustrated History of organ transplantation*. Ed. Laboratoires Sandoz, Paris.
- [3] SANDARS NK. (1995) *Prehistoric Art in Europe*. Pelican History of Art, Yale University Press, 2nd Ed., New Haven and London, 1985-1995

- [4] CONOLLY BW, BENANZIO M. Cosmas and Damian Revisited, in Lanzetta, M., Dubernard, J-M. (Eds.) *Hand Transplantation*. Springer, 2007.
- [5] HAWASS Z (2004) *Hidden Treasures of Ancient Egypt*. National Geographic Ed., Washington, 2004.
- [6] PARROT A. (1970) *Les Merveilles du Louvre*. Paris, Hachette.
- [7] TYLDESLEY J. (2009) *The Pharaohs*. London, Oxford, Quercus Publishing Plc.

- [8] PEARSON G, RUBERG R. (2009) A history of Plastic Surgery. In *Plastic Surgery: Indications and Practice. Volume I*. First edition. Edited by Chung K, Disa J, Gosain A, Kinney B, Rubin P. Philadelphia: Saunders Elsevier; 2009: 3-6
- [9] HIBBARD H. (1986) *The Metropolitan Museum of Art*. Harrison House, New York.
- [10] HONOUR H; FLEMING J. (2005) *A World History of Art*. 7th Ed., Laurence King Publishing, London.
- [11] GOLDWYN RM. The early history of plastic and reconstructive surgery. *Plast Reconstr Surg* 2008, 121:1489-1498
- [12] GURUNLUOGLU R, GURUNLUOGLU A: Paulus Aegineta, a seventh century encyclopedist and surgeon: his role in the history of plastic surgery. *Plast Reconstr Surg* 2001, 108:2072-2079
- [13] MORAIN WD: History and plastic surgery: systems of recovering our past. *Clin Plast Surg* 1983, 10:595-601
- [14] MANCA J; BADE P; COSTELLO S. (2007) *1000 Sculptures of Genius*. Parkstone International.
- [15] SINGH M. (1968) *l'Art de l'Himalaya, la Peinture et la Sculpture*. Livres d'Art Unesco.
- [16] LASCARATOS J, COHEN M, VOROS D: Plastic surgery of the face in Byzantium in the fourth century. *Plast Reconstr Surg* 2000, 106:517-518
- [17] LASCARATOS J, COHEN M, VOROS D: Plastic surgery of the face in Byzantium in the fourth century. *Plast Reconstr Surg* 1998, 102:1274-1280
- [18] KALANTAR-HORMOZI A: A brief history of plastic surgery in Iran. *Arch Iran Med* 2013, 16:201-206
- [19] LINFERT C. (1972) *Jérôme Bosch*. La Bibliothèque des Grands Peintres. Éd du Cercle d'Art, Paris.
- [20] ARIS A. (2002) *A Medicina na Pintura*. Chaves Ferreira, Publicações, S.A., Lisboa, 2002.
- [21] VASARI G. (1585) *Vita di Lionardo da Vinci, Pittore et Scultore Fiorentino*. in Goldscheider L. *Leonardo da Vinci-The Artist*. 2nd. Ed., Phaidon Press, Oxford and London, 1945.
- [22] BONDANELLA J; BONDANELLA P. (1998) *Giorgio Vasari. The Lives of the Artists. Translated with an Introduction and Notes*. Oxford World's Classics. 2nd Ed. Oxford University Press, New York and Oxford, 1991-1998
- [23] AMBROISE PARÉ [1585 – (1969)] *Œuvres Complètes. (Fac-simile, préfacé par VERNEJOU et J. ROSTAND)*. Ed. Louis Pariente, Paris, 1969.
- [24] PARÉ A. [1585 –(1964)] *Des Monstres, des Prodiges et des Voyages*. Texte Etabli et Présenté par Patrice Bousset. Livre Club du Livraire, Paris, 1964.
- [25] MARTIN S. (2006) *Le Guide du Musée du Quai Branly*, Paris.
- [26] SHANES E. (1994) *Dalí*. Editorial Estampa Lda, Lisboa, 1994.
- [27] SHELLEY M. [1818-(2007)] *Frankenstein, or the Modern Prometheus*. Ed. Susan J. Wolfson. New York: Pearson Longman, (1818)-2007
- [28] BARONE A, TODISCO M, LUDOVICHETTI M, GUALINI F, AGGSTALLER H, TORRÉS-LAGARES D, ROHRER MD, PRASAD HS, KENEALY JN. A Prospective, Randomized, Controlled, Multicenter Evaluation of Extraction Socket Preservation Comparing Two Bovine Xenografts: Clinical and Histologic Outcomes. *Int J Periodontics Restorative Dent*. 2013 November/December;33(6):795-802. doi: 10.11607/prd.1690.
- [29] SIMION M, FONTANA F. Autogenous and xenogeneic bone grafts for the bone regeneration. A literature Review. *Minerva Stomatol*. 2004 May;53(5):191-206.
- [30] GOMEZ M, CASAL D: The turbocharged Becker flap: a simple variation that allows coverage of most of the dorsum of the hand. *European Journal of Plastic Surgery* 2011, 34:211-213

- [31] CARVALHO R, CASAL D, ZAGALO C, ROSA J: Radix nasi Transposition Flap for Medial Canthus and Nasal Sidewall Defects. *Dermatol Surg* 2011, 37:1777-1780
- [32] ROSA J, CASAL D, MONIZ P: Upper eyelid reconstruction with a horizontal V-Y myotarsocutaneous advancement flap. *J Plast Reconstr Aesthet Surg* 2010, 63:2013-2017
- [33] MONIZ P, CASAL D, ROSA J: Nasolabial skin cancer recurrence and incomplete excision: a five year review. *Skin Cancer* 2010, 25:43-57
- [34] ROSA J, CASAL D, MONIZ P: Reconstruction of upper eyelid defects with V to Y myotarsocutaneous advancement flaps. *Skin Cancer* 2009, 24:143-157
- [35] HALLOCK GG: A history of the development of muscle perforator flaps and their specific use in burn reconstruction. *J Burn Care Rehabil* 2004, 25:366-371
- [36] CARREL A, GUTHRIE CC: Results of a replantation of the thigh. *Science* 1906, 23:393-394
- [37] KOCHER MS: History of Replantation - from Miracle to Microsurgery. *World J Surg* 1995, 19:462-467
- [38] CASAL D, GOMEZ MM, ANTUNES P, Candeias H, Almeida MA: Defying standard criteria for digital replantation: A case series. *Int J Surg Case Rep* 2013, 4:597-602
- [39] PEDERSON WC: Replantation. *Plast Reconstr Surg* 2001, 107:823-841
- [40] KOMATSU S, TAMAI S: Successful replantation of a completely cut-off thumb. *Plast Reconstr Surg* 1968, 42:374
- [41] TSAI TM, BREYER JM, PANATTONI JB: History of microsurgery: curiosities from the sixties and seventies. *Microsurgery* 2013, 33:85-89
- [42] CHANG J, JONES N: Twelve simple maneuvers to optimize digital replantation and revascularization. *Tech Hand Up Extrem Surg* 2004, 8:161-166
- [43] DOS REMEDIOS C, LEPS P, SCHOOF M: [Results of 46 digital replantations. With a minimal follow-up of one year]. *Chir Main* 2005, 24:236-242
- [44] TAMAI S: History of microsurgery. *Plast Reconstr Surg* 2009, 124:e282-294
- [45] NOAMAN HH: Microsurgery in children: history, indications, precautions, and differences from that of adults. *Microsurgery* 2008, 28:83-84
- [46] SCHULTHEISS D, DENIL J: History of the microscope and development of microsurgery: a revolution for reproductive tract surgery. *Andrologia* 2002, 34:234-241
- [47] TAMAI S: History of microsurgery--from the beginning until the end of the 1970s. *Microsurgery* 1993, 14:6-13
- [48] GOMEZ MM, CASAL D: Reconstruction of large defect of foot with extensive bone loss exclusively using a latissimus dorsi muscle free flap: a potential new indication for this flap. *J Foot Ankle Surg* 2012, 51:215-217
- [49] CUNHA TF, SOARES MELANCIA TA, ZAGALO FERNANDES RIBEIRO CM, ALMEIDA DE BRITO JA, ABREU MIGUEL SS, ANDRE ABREU ESTEVES BOGALHAO DO CASAL D: Risk factors for surgical site infection in cervico-facial oncological surgery. *J Craniomaxillofac Surg* 2012, 40:443-448
- [50] GRILLO HC: The history of tracheal surgery. *Chest Surg Clin N Am* 2003, 13:175-189
- [51] THIONE A, CAVADAS PC, CARBALLEIRA A: Urethra Reconstruction With a Prelaminated Pedicled Anterolateral Thigh Flap: A Case Report. *Ann Plast Surg* 2013
- [52] CARTY MJ, ZUKER R, CAVADAS P, PRIBAZ JJ, TALBOT SG, POMAHAC B: The case for lower extremity allotransplantation. *Plast Reconstr Surg* 2013, 131:1272-1277
- [53] CAVADAS PC, IBANEZ J, THIONE A: Surgical aspects of a lower face, mandible, and tongue allotransplantation. *J Reconstr Microsurg* 2012, 28:43-47
- [54] CAVADAS PC, LANDIN L, THIONE A, RODRIGUEZ-PEREZ JC, GARCIA-BELLO MA, IBANEZ J, VERA-SEMPERE F, GARCIA-

- COSMES P, ALFARO L, RODRIGO JD, CASTRO F: The Spanish experience with hand, forearm, and arm transplantation. *Hand Clin* 2011, 27:443-453, viii
- [55] CAVADAS PC, IBANEZ J, THIONE A, ALFARO L: Bilateral trans-humeral arm transplantation: result at 2 years. *Am J Transplant* 2011, 11:1085-1090
- [56] PETRUZZO P, LANZETTA M, DUBERNARD JM, LANDIN L, CAVADAS P, MARGREITER R, SCHNEEBERGER S, BREIDENBACH W, KAUFMAN C, JABLECKI J, et al: The International Registry on Hand and Composite Tissue Transplantation. *Transplantation* 2010, 90:1590-1594
- [57] LANDIN L, CAVADAS PC, NTHUMBA P, IBANEZ J, VERA-SEMPERE F: Preliminary results of bilateral arm transplantation. *Transplantation* 2009, 88:749-751
- [58] LEON X, PUJOL A, LOPEZ M, GARCIA J, PONS G, SANUDO JR, MASIA J, QUER M: [Larynx transplant: a therapeutic option for the 21st century? Literature review]. *Acta Otorrinolaringol Esp* 2008, 59:127-138
- [59] DELAERE PR: Tracheal transplantation. *Curr Opin Pulm Med* 2012, 18:313-320
- [60] LANDIN L, CAVADAS PC, CARRERA A, FONTDEVILA J, NAVARRO C: Human face/scalp alloflap harvesting technique. *Plast Reconstr Surg* 2007, 119:1114-1115
- [61] MONIZ P, CASAL D, MAVIOSO C, CASTRO JVE, ALMEIDA MA: Stevens-Johnson Syndrome and Toxic Epidermal Necrolysis A 15-Year Retrospective Study. *Acta Médica Portuguesa* 2011, 24:59-70
- [62] SILVA-GUERRA A, RAMOS L, S. F, J. F, CASAL D, SILVA R, RASTEIRO D, CAIADO C, MONIZ P, FRADINHO N, et al: Dermal regeneration template for lower extremity burns. *Burns* 2009, 35 S S1-S47
- [63] CASAL D, MONIZ P, RAMOS L, NETO C, CAIADO C, MAVIOSO C, MILLAN G, VIDEIRA-CASTRO J, ANGELICA-ALMEIDA M: HIV infection in Burn Patients and its Impact on Mortality, Morbidity and Pattern of Infecting Organisms and Microbial Resistance in a Portuguese Burn Unit. *Journal of Burn Care and Research* 2008, S2:S87
- [64] ANGELICA-ALMEIDA M, ANACLETO J, MAVIOSO C, CASAL D, MONIZ P, VIDEIRA-CASTRO J: Experience on the use of a high-pressure water jet system in a Burn Care Unit. *Burns* 2007, 33 S:S114-S115
- [65] ELDAD A, SIMON GA, KADAR T, KUSHNIR M: Immediate dressing of the burn wound--will it change its natural history? *Burns* 1991, 17:233-238
- [66] PINNEGAR MD, PINNEGAR FC, 3rd: History of burn care. A survey of important changes in the topical treatment of thermal injuries. *Burns Incl Therm Inj* 1986, 12:508-517