

## 1

## Africa

Few cultural transformations in human history have compared in magnitude with the emergence of the earliest civilizations such as those found in the cradle of humankind, Africa. During the Neolithic Period, productive agriculture in the flood plains of great rivers allowed local non-nomadic populations to expand, and this led to the building of the world's first cities. The consequences were wide-ranging and profound. They included organized warfare, which led to frequent serious injuries; the appearance of new diseases associated with high population densities; the elaboration of religion, including novel ideas about death and the afterlife; and the invention of writing, which was needed to record laws, food distribution patterns, and so on. War-related and other injuries promoted the practice of surgery, diseases led to the emergence of medicine, and these developments – together with certain burial practices – fostered knowledge of anatomy. Thanks to the invention of writing, some of this knowledge was recorded. Nowhere was this historical pattern more clearly exemplified than in ancient Egypt. The earliest surviving Egyptian writings pertinent to medicine and anatomy date back some 4000 years, but they seem to refer to texts around 1000 years older, which are no longer extant.

When the great Bronze Age empires declined and iron-based technology spread, long-distance trade increased, and ideas were carried along the trade routes. For instance, knowledge from ancient Egypt, as well as the former empires of the Middle East, was conveyed to the Greek city states during the first millennium BCE, contributing to the development of Hippocratic medicine. Two or three centuries later, this influence was reciprocated. The burgeoning of knowledge in Alexandria owed the most to Greek rationalism and naturalism, although the legacy of ancient Egypt was still apparent.

With the erosion of the Western Roman Empire and the concomitant decline of Alexandrian learning during the early centuries CE, Egypt ceased to make salient contributions to anatomical or other knowledge. Such learning as survived from the heyday of Alexandria was scattered far and wide – to be brought back together in the eighth and ninth centuries CE under the influence of the Caliphate of Baghdad (see Chapter 4). A few hundred years later, some of that corpus of knowledge was translated in Europe. The more ancient Egyptian knowledge, however, did not become known to Europe (or the rest of the post-Classical world) until the later nineteenth century, when it became possible to translate hieroglyphic writings into European languages. The quality and detail of that ancient knowledge surprised the translators, and still has the power to surprise the reader.

## 1.1 Egypt

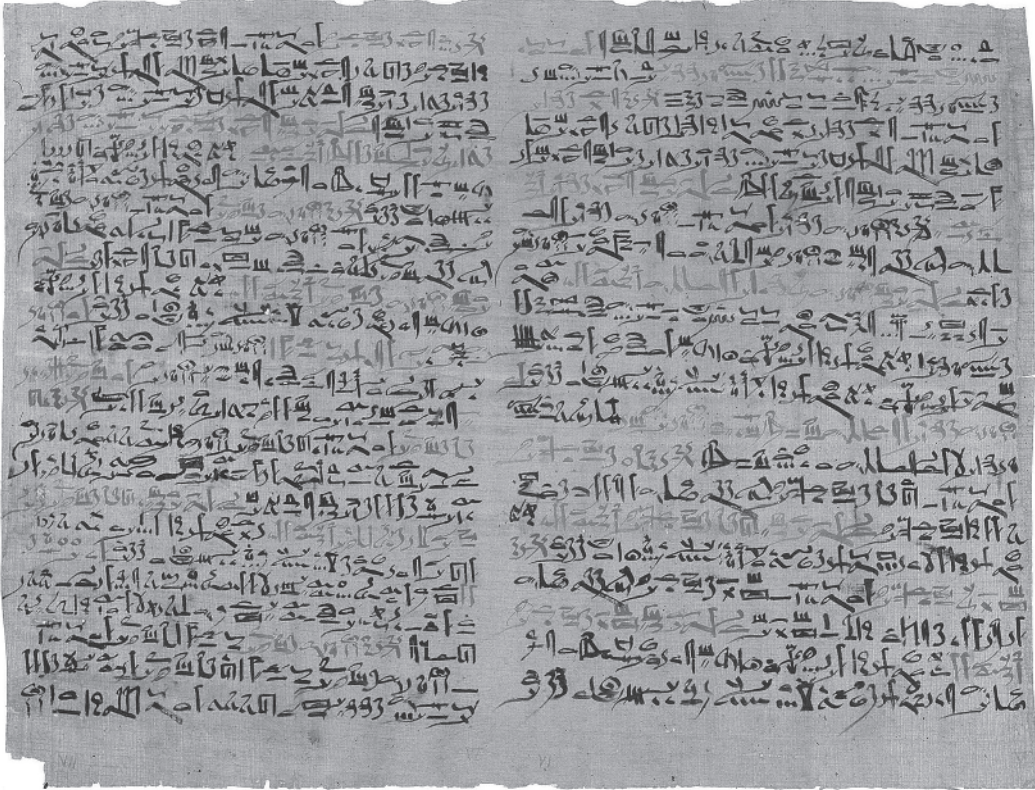
Historians and archeologists have spent much time researching and excavating ancient Egypt. Much of that work has focused on the visible aspects of ancient Egyptian society; however, research shows that little recognition has been given to Egypt's contribution to the anatomical sciences, even though the Egyptians were regarded as great physicians of their day. They were famously known for the process of embalming and mummification, which allowed them to have invaluable exposure to human anatomy. As devoted record-keepers, the ancient Egyptians chronicled a vast amount of their knowledge and experience on papyrus. Some of the papyri have shed light on what ancient Egypt knew about anatomy, including the Edwin Smith Papyrus (1700 BCE), the Ebers Papyrus (1500 BCE), and the Kahun Gynecological Papyrus (1825 BCE). These papyri contain a wealth of information on surgery, healing, skin diseases, stomach ailments, medicines, the head, dentistry, gynecology, and diseases of the extremities. Centuries later, during the Alexandrian Period, anatomy became a formally recognized discipline in the city of Alexandria, where it was led by two of the greatest anatomical scholars: Herophilus and Erasistratus. Although they did not have access to technologically advanced labs, their primitive studies and investigations produced the cornerstone on which the later study of anatomy was built. This section examines ancient Egypt's contribution to the anatomical sciences and how it influenced our current knowledge of human anatomy.

### 1.1.1 The Edwin Smith Papyrus

The Edwin Smith Papyrus is regarded as one of the most significant medical and anatomical references discovered in ancient Egypt. Dating back to 1700 BCE, it is one of the oldest known documents relating to anatomy and surgery. It was written by an anonymous author, who appears to have been attempting to salvage content from an older script dating back to 3000 BCE. An American living in Egypt, Edwin Smith, purchased the script in Luxor in 1862 under controversial circumstances. Some believe that he purchased it from Mustafa Agha, an Egyptian businessman, while others claim he obtained it from tomb raiders. The manuscript was donated to the New York Historical Society in 1906, and later translated by James Henry Breasted in 1930. It appears to have been intended as a surgical guidebook, starting with cases relating to the head and moving systemically down the body. The Edwin Smith Papyrus clearly illustrates the knowledge of the ancient Egyptians in anatomy, with 48 cases divided into *examination*, *diagnosis*, and *treatment* (Figure 1.1). The most helpful record and insight into the expertise of the Egyptians in anatomy is provided by the *examination* outline. The Egyptians' observational skills and systemic analysis were impressive, as they documented the anatomy associated with neurological deficits, musculoskeletal injuries, and the vascular and reproductive systems.

### 1.1.2 The Ebers Papyrus

Like the Edwin Smith Papyrus, the Ebers Papyrus was also purchased in Luxor by Edwin Smith in 1862. The Egyptologist George Ebers, for whom it is named, bought it from him in 1872. The Ebers Papyrus is by far the lengthiest of the medical papyri, and is dated by a passage to 1500 BCE, close to the date of the Edwin Smith Papyrus; however, other references in the text date the content of the script to 3000 BCE – again, like the Edwin Smith Papyrus. However, unlike the Edwin Smith Papyrus, the Ebers Papyrus is composed of medical guidance in reference to body systems. It incorporates references to many diseases and a comprehensible pharmacopeia. There is also a very illustrative and detailed picture of the cardiovascular system and its distribution, which will be discussed later.



**Figure 1.1** The Edwin Smith Papyrus, the world's oldest surviving surgical document. Written in hieratic script in ancient Egypt around 1600 BCE, the text describes anatomical observations and the examination, diagnosis, treatment, and prognosis of 48 types of medical problems in exquisite detail. Plates 6 and 7 of the papyrus, pictured here, discuss facial trauma. (Source: [http://en.wikipedia.org/wiki/File:Edwin\\_Smith\\_Papyrus\\_v2.jpg](http://en.wikipedia.org/wiki/File:Edwin_Smith_Papyrus_v2.jpg).)

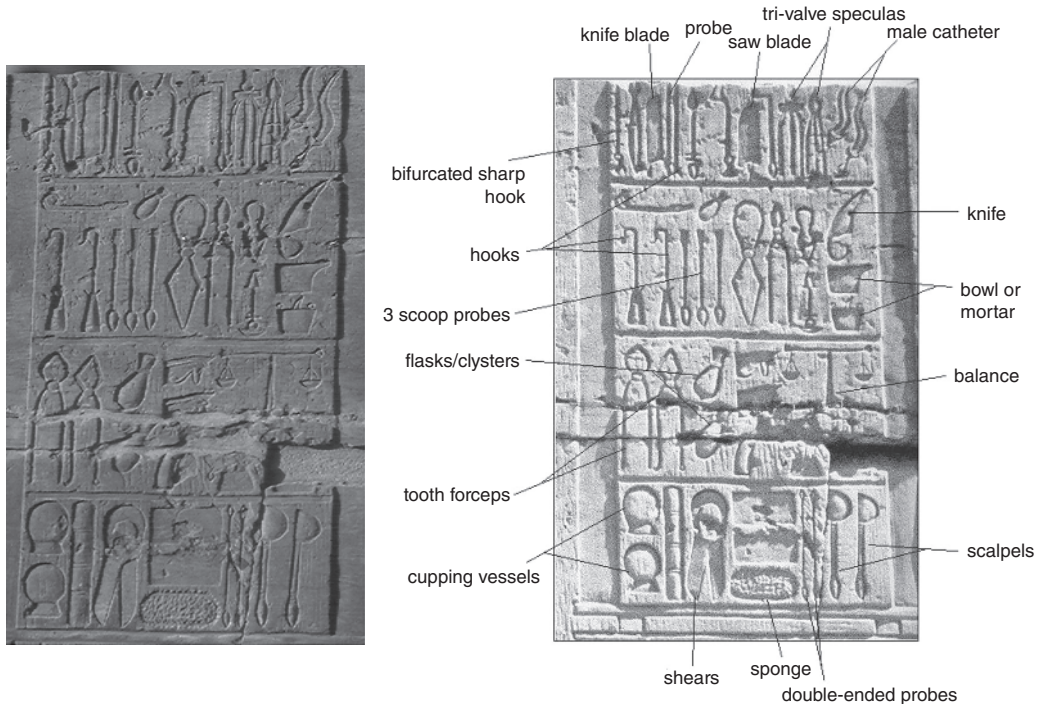
### 1.1.3 The Kahun Papyrus

The Kahun Papyrus is significant because it reveals the hypotheses and beliefs of the ancient Egyptians regarding gynecology and pelvic anatomy. It was discovered by Flinders Petrie in 1889 at the Fayum site of Lahun and dated back to the Middle Kingdom of 1825 BCE.

### 1.1.4 Egyptian Anatomy in General

In the foreword of the translation of the Edwin Smith Papyrus (page XVI), Breasted acknowledged the anatomical mastery of the ancient anatomist, as he wrote: “He knew of the cardiac system and was surprisingly near recognition of the circulation of the blood, for he was already aware the heart was the center and the pumping force of a system of distributing vessels. He was already conscious of the importance of the pulse and had probably already begun to count the pulse, a practice heretofore first found among the Greek physicians of the third century B.C. in Alexandria.”

The ancient Egyptian anatomist was the embalmer. Embalmers held an honorable priestly position in Egyptian society, where their role was to prepare the dead for life beyond the grave, using extensive and elaborate techniques designed to preserve the human body. The embalmer's sole interest was to preserve the body ritually, but the processes used and



**Figure 1.2** Relief in the outer wall of the Temple of Kom Ombo. The depressions represent the tools used by the ancient Egyptians. Some have still not been identified, and others have questionable functions. (Source: With permission from Loukas et al. 2011.)

developed for mummification led to discoveries that would later contribute significantly to the study of anatomy (Figure 1.2).

Much credit is also due to the ancient Egyptian physicians or surgeons, known as the *swmw*, from the hieroglyph for “arrow.” Their use of limb prosthetics exemplifies their advanced knowledge for their time (Figure 1.3). This knowledge, transcribed into the Ebers and Edwin Smith papyri, was referred to by later physicians, not only for assistance with common ailments, but also to aid in diagnosing and treating a variety of conditions ranging from head injuries to trans-sphenoidal surgery. The detail seen in these papyri is evidence of the amount of knowledge the ancient anatomists were able to collect and record on the basis of their experiences.

### 1.1.5 Neurological Anatomy

The ancient Egyptian embalmers were experts at carefully removing and preserving organs from body cavities during their mummification ceremonies. Organs such as the brain were thought to have little overall significance for an individual in the realm of the afterlife. Surprisingly, ancient Egyptians were the first to apply an advanced technique of trans-sphenoidal access to the cranial vault and remove the brain without disfiguring the face. The use of this technique in ancient Egypt is evidenced by various studies on mummies and instruments found in archeological digs.

The Edwin Smith and Ebers papyri contain a plethora of cases relating to cranial and spinal injuries, as knowledge of how to treat these injuries was crucial during times of war.

**Figure 1.3** Artificial big toe, found on the foot of an ancient Egyptian mummy. The toe has been dated to 1069–664 BCE and is on display at the Cairo Museum in Egypt. It is carved or made from wood and leather, and is attached to the foot by a sewn leather wrapping. (Source: Released from Copyright, <http://www.experiment-resources.com/ancient-medicine.html>, with permission from Loukas et al. 2011.)



The papyri address superficial lacerations, deep scalp wounds, skull fractures, and vertebral subluxation and dislocations. This in turn offers us a glimpse into the ancient Egyptians' repository of anatomical knowledge. In 1925, Breasted met Harvey Cushing (the father of American neurosurgery) and shared with him the first appearance in ancient medical literature of the word "brain," in the Edwin Smith Papyrus. Because of the emphasis on cranial and spinal injuries in these papyri, they are of great use to neurosurgeons today, as they provide a historical perspective.

Cases 4, 5, and 6 of the Edwin Smith Papyrus shed light on the anatomical knowledge the Egyptians possessed in treating severe head injuries accompanied by evidence of basilar skull fractures and meningismus. Cases 4 and 5 concern skull fractures and methods of diagnosis based on severity, while Case 6 introduces a skull fracture, dural laceration, and cerebrospinal fluid leakage. Further mention of the area of skull fracture indicates that the Egyptians had started to map the human skull. Case 7 makes mention of symptoms attributed to compound skull fractures penetrating the frontal air sinus, while Case 19 alludes to a zygomatic-temporal fracture or wound with subsequent deafness and aphasia associated with damage to Heschl's gyrus and to Broca's and Wernicke's areas. The detail and attention given to the treatment of these disorders allow us to appreciate the anatomical knowledge the Egyptians were able to assimilate.

The papyri also contain valuable information regarding vertebral and spinal cord injuries and subsequent symptoms, including paraplegia, persistent erections, seminal emissions, and urinary incontinence. The Egyptians were quick to make a connection between spinal cord injuries and paralysis or even death. Physicians were able to differentiate between different degrees of vertebral injury based on symptoms, as seen in Cases 31, 32, and 33 of the Edwin Smith Papyrus. Dislocation or a crushed vertebra produced the most severe symptoms, while a cervical vertebral sprain was diagnosed on the basis of stiff head rotation.

Later, during the Alexandrian Period, Herophilus (c. 335–280 BCE) is credited with the discovery and development of anatomical sciences in Egypt. He gave a description of the prolongation of the rhombencephalon, which he termed the "spinal cord" and believed was the source of the peripheral nerves. He also distinguished between motor and sensory nerves and proved the connection between loss of motor nerve function and paralysis. He described several cranial nerves, including the trigeminal, facial, auditory, and hypoglossal. He also identified the meninges and ventricles, and recognized the division between the cerebellum (*paraenkephalis*) and cerebrum (*enkephalos*). He was the first to assign to nerves the function of nerve impulses.

### 1.1.6 Cardiovascular Anatomy

“The beginning of the physician’s secret: knowledge of the heart’s movement and knowledge of the heart” is the opening statement on the anatomical-physiological section of the Ebers Papyrus. The Egyptians regarded the heart as the central organ in the human body; they believed that it was the motor organ and the seat of intelligence, emotions, and desire. During the mummification process, the heart was kept *in situ* and was meticulously preserved to ensure its continued well being, for its loss meant annihilation in the second life. The heart is depicted in hieroglyphics as a character with a black arrow, or sometimes a vessel with an inlet and outlet as seen in the Edwin Smith Papyrus. Also significant is the attempt to identify the base and apex of the heart and the bilateral symmetrical projections, namely the pulmonary artery and aorta, in ancient Egyptian drawings.

The Ebers Papyrus records even greater knowledge of internal medicine, including a treatise on the heart and the circulation. The first link made between the heart and the pulse is found in this papyrus: “From the heart arise the vessels which go to the whole body ... if the physician lay his finger on the head, on the neck, on the hand, on the epigastrium, on the arm or the leg, everywhere the motion of the heart touches him. Coursing through the vessels to all the members.” It is also important to note that the Egyptians were the first to associate air with the blood and cardiovascular system.

The Ebers Papyrus goes into detail in mapping the circulation in the cardiovascular system, including the number of vessels reaching the nostrils, inferior temples, extremities, testicles, liver, lung, and bladder. However, its authors did not believe that these vessels were conduits for blood, but rather for the element of the organ they supplied. For example, “There are 2 vessels to his testicles; it is they which give semen” illustrates their belief that these vessels from the heart carried semen rather than blood.

During the Alexandrian Period, Herophilus’ contribution to cardiovascular medicine was his most important work in terms of scientific achievement. He was the first to recognize the difference between arteries and nerves. Before Herophilus, nerves, tendons, arteries, and veins were all referred to as “cords,” represented as an erect penis in hieroglyphics. Herophilus is also recognized for distinguishing between arteries and veins; he described the arteries as carrying blood from the heart and the veins as returning blood to the heart. He described the anatomy of the heart valves and, along with Erasistratus (c. 304–250 BCE), demonstrated how blood was prevented from flowing backwards under normal conditions. Erasistratus may be considered the founder of physiology. He named the trachea and described the heart valves and chordae tendinae.

### 1.1.7 Reproductive Anatomy

The Kahun Papyrus, a gynecological text, enables us to examine ancient Egyptians’ concept of human reproduction. They had two theories in regard to conception. One view was that the man’s semen originated from the spinal cord: this was the belief spread by Egyptian priests who worshiped bulls and perceived that the bull’s phallus was an extension of the spine. The other hypothesis was that the heart was the source of the semen, as mentioned in the Ebers Papyrus in reference to the two vessels traveling from the heart to the testicles. The ancient Egyptians believed that menstruation ceased during pregnancy because the blood was diverted to sustain the embryo. An interesting note is that they did not understand the maternal role in reproduction, except in serving as an incubator for the fetus; however, they appreciated the vital role of the placenta as a source of nourishment.

Ancient Egypt did not utilize the last menstrual period date to confirm pregnancy. According to Hippocratic writings (460–377 BCE), they instructed the female to embed an onion bulb

deep in her vagina overnight. If the onion's strong odor was detected on the patient's breath, it confirmed the diagnosis. It was later posited that the absorption of the onion's sulfuric compounds into the woman's blood via the submucosal blood vessels, which were engorged due to pregnancy, might have been responsible for this "onion breath." It is unlikely, however, that the ancient Egyptians understood the anatomical and physiological reasoning behind this method.

Other gynecological complications facilitated ancient Egypt's understanding of the female reproductive system. There are indications in the Ebers Papyrus of ancient Egyptians suturing postpartum perineal tears and lacerations. Records have also shown references to treatment of long-term complications of pregnancy such as a prolapsed uterus. More interestingly, mention is made of vesicovaginal fistulas.

There is no way of knowing how much of the surgical, medical, and anatomical knowledge of ancient Egypt is irretrievably lost. However, what survives of that knowledge, exemplified by the three papyri discussed here, is remarkable. Thanks mostly to their embalming practices and their pioneering work in surgery, the Egyptians of the second millennium BCE achieved a surprisingly accurate and detailed knowledge of human anatomy. However, although they identified and named a wide range of structures, their ideas about the functions associated with those structures (physiology) were very different from ours. During the "renaissance" of anatomical knowledge in Egypt, in the Alexandrian Period, Greek rationalism and naturalism led to more refined descriptions and to a grasp of physiology that we find easier to recognize. Indeed, our present-day physiology has descended, in part, from the surviving works of Herophilus and Erasistratus.

## 1.2 Algeria

### 1.2.1 Jean Baptiste Paulin Trolard

A hundred years after his death, Jean Baptiste Paulin Trolard's name endures in the medical literature primarily because of his work relating to the anastomotic veins of the cerebral circulation (Figure 1.4). Specifically, the great anastomotic vein, or the vein of Trolard, known to all neurosurgeons, records a portion of Trolard's contribution to neuroanatomy. Algeria has also remembered this influential colonist because of his life's work as a physician, professor, humanitarian, environmentalist, and French nationalist. Trolard fought deforestation, injustice, epidemics, and bureaucracy in northern Africa, and tragically died in the midst of these struggles.

#### 1.2.1.1 Early Life

Trolard was born on November 27, 1842 in the town of Sedan (Ardennes), France. During this time, the French were involved in a long and violent conquest of Algeria, which began in 1830 and was completed in the early 1900s, at a cost of approximately one million Algerian lives. Tens of thousands of Europeans, including a large French contingent, settled and farmed much of Algeria, and populated the capital city of Algiers. This mass immigration also marked the arrival of Paulin Trolard.

Trolard studied medicine at the Algiers Preparatory College of Medicine and began his medical career as a municipal physician in Saint Eugene, a suburb of Algiers. In 1861, the College named him anatomy prosector, and in 1868 he defended his doctoral thesis in Paris, entitled "Research on the Anatomy of the Venous System of the Encephalon and Skull."

In 1869, Trolard became the Chair of Anatomy at the Algiers Preparatory College of Medicine, a post he held until 1910. As a professor, he had a very clear method of teaching that was free of unnecessary erudition, and he published several texts concerning the organization of medical studies.



**Figure 1.4** Jean Baptiste Paulin Trolard (1842–1910). (Source: Courtesy of the Bibliothèque interuniversitaire de médecine et d'odontologie, Paris, France.)

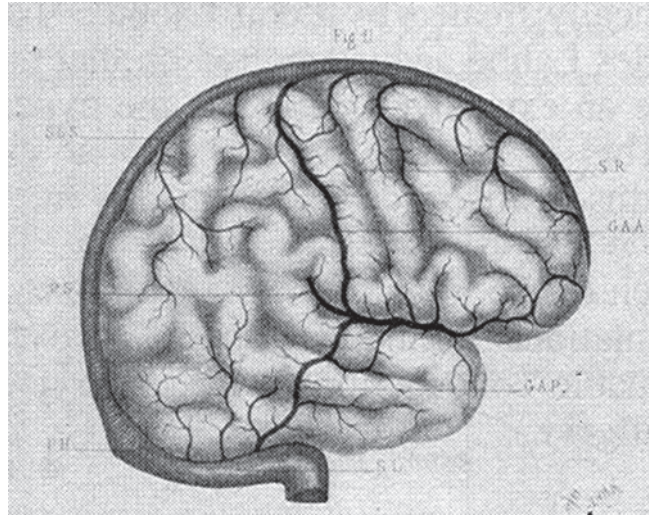
### 1.2.1.2 Neuroanatomical Descriptions

In his doctorate thesis of 1868, and then in a subsequent publication in 1870, Trolard described one of the three major anastomotic veins of the cerebral circulation. Interestingly, in his early anatomical descriptions of his “great annectant” vein, which became known as the “great anastomotic vein” or the “vein of Trolard” (Figure 1.5), Trolard mentioned his contemporary Charles Labbé’s (1851–1889) description of the vein that bears Labbé’s name. This latter vessel forms the major communication between the superior and inferior cerebral veins, creating an anastomotic route between the superior sagittal sinus and the middle cerebral vein and, therefore, the cavernous sinus. It is normally present in the non-dominant hemisphere and found at the level of the postcentral sulcus. The vein of Trolard may be duplicated and is usually directed forward against the direction of flow of the superior sagittal sinus. Aran et al. indicated that injury to this large, superficial drainage vein, recognizable by the sixth or seventh month of fetal life, may result in venous hypertension, with manifestations that include seizure and focal neurological deficits. Labbé believed that adding the modifier “antérieure” to the vein of Trolard was appropriate:

One can find, behind the vein described by Monsieur Trolard, another vein, almost equally important, like the former playing an anastomotic role between the sinuses and that has never been reported before. The last one should be called the greater anastomotic posterior cerebral vein.

Trolard also described a venous anastomosis at the base of the brain, which is the venous equivalent of the circle of Willis. This venous “circle” is composed of the anterior cerebral and communicating veins, the basal vein of Rosenthal, and the posterior communicating and lateral mesencephalic veins (Figure 1.6). While in Algiers, Trolard published various neuroanatomical papers on other topics, including olfaction, the middle meningeal veins, the joints of the spine,

**Figure 1.5** Drawing taken from Labbé's work on the superficial cerebral veins of the lateral brain, demonstrating the veins of Trolard (GAA) and Labbé (GAP). Interestingly, Trolard's original description of the vein that bears his name did not include figures.



**Figure 1.6** Cadaveric photo of the base of the brain. For reference, note the olfactory tracts and midbrain in the cross-section. Note the venous ring encircling the mammillary bodies and the floor of the third ventricle. The anterior cerebral veins are seen leaving the longitudinal fissure. Note the anterior communicating vein between the two anterior cerebral veins and the deep Sylvian vein (upper arrow). An anastomotic vein (lower arrow) is seen linking the basal vein of Rosenthal just posterior to the mammillary bodies. Note that the floor of the third ventricle has been perforated. (Source: With permission from Loukas et al. 2010.)



and the spinal cavity. He wrote that the vertebral vein acted like a dural venous sinus, as it surrounds the vertebral artery extracranially via multiple secondary channels linked by several septae and trabeculae. Trolard described a “net” or venous plexus, which now bears his name, and which surrounds the hypoglossal nerve while within the hypoglossal canal. He also correctly described the spinal dural cul-de-sac as terminating at the second sacral vertebrae, even in infants, which went against classical descriptions. Although Luschka studied the uncovertebral joints in 1858, Trolard is given credit for naming them in 1892. He described a ligament that connects the anterior spinal dura mater to the posterior longitudinal ligament

and called it the “ligament a sacral arterius.” The so-called “curtain sign” is due to the ligament of Trolard (sacro-dural ligament of Trolard) and its partitioning of blood/tumor anterior to the spinal dural sac. Although Cruveilhier, Luschka, Henle, and Meyer had described the lacunae lateralis earlier, they carry the eponym “Trolard” and were described by him as the “lacs sanguins.” Trolard is credited with first describing connections of regional veins to the arachnoid (Pacchionian) granulations and observing that

The veins which open into the superior longitudinal sinus are described as opening into that canal in a direction contrary to the blood current. This is not quite true. The little veins, especially the anterior ones, open directly, or from before backwards, into the sinus. As to the two or three large veins, they communicate with the sinus from behind forward. But one must not overlook the fact that these anastomotic veins place in communication the superior longitudinal sinus with the superior petrosal and lateral sinuses. These anastomotic veins which are accessory to the great sinus must have the same direction that this last one had.

### 1.2.1.3 Battling Epidemics in Algeria

Trolard also dedicated much of his career to fighting contagious diseases and epidemics in Algeria. He was a major proponent of free vaccination for all indigent peoples and was responsible for procuring bacteriology and parasitology laboratories in Algiers. Even more remarkable was his work in combating rabies, a usually fatal disease at that time. Fascinated by Louis Pasteur’s work on rabies and vaccination, Trolard went to Paris to visit him and to ask him to create an Institute in Algiers for the investigation of vaccination against rabies. Pasteur agreed, and in 1894, Professors Trolard and Henri Soulié, both of the Algiers School of Medicine and Pharmacy, founded the L’Institut Pasteur d’Algérie and established a rabies and smallpox vaccine department. Trolard went on to develop vaccines for anthrax and sheep pox. Although he lacked material resources to upgrade laboratories and develop research extensively, the Institute became the center of scientific research for Pasteur’s methods in Algeria.

### 1.2.1.4 Conflict with France

For his efforts in studying the anatomy and physiology of the venous system, Trolard was awarded the Lallemand Prize (1800 francs) by the Academy of Sciences in Paris in 1893. Nevertheless, his commitment was to his work in Algeria. In addition to his professional responsibilities at the medical school, his duties at the Pasteur Institute, and his involvement with the League of Reforestation, Trolard was also involved in the local governance of Algiers, serving on the local governing council for much of his time in Algeria.

Despite his various positions, Trolard was described as “ennemi de la notoriété et dédaigneux des honneurs” (an enemy of notoriety and disdainful of honors). This led him into direct conflict with French authorities, particularly with the Gouvernement Général and the délégations financières with regards to his reforestation efforts. Paris disagreed with and was openly critical of his views, and Trolard regularly countered with his own scathing criticisms, often via his numerous publications. This predisposition to flout authority would eventually lead to the end of his career and, possibly, his death.

### 1.2.1.5 One Man’s Legacy

Jean Baptiste Paulin Trolard, physician, anatomist, husband, and father, died in Saint-Eugène, Algeria on April 13, 1910, curiously soon after being “expelled” from Algeria. He had hoped to retire to his native France. Although he will forever be remembered by the anatomical structures bearing his name, specifically the greater anastomotic vein, his life meant much

more to the countless people saved through his efforts, to the countless students he trained as physicians, and to the country he strove to make better. Algeria has remembered Trolard via a town, a church, and a street bearing his name.

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