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Basics of the Medieval Arabic Medicine: The Vascular Systems in the Canon of Medicine of Avicenna Incorporating a Translation of a Part of the First Book

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Keywords: *anatomy, blood-system, Islamic medicine, Avicenna, Ibn Sīnā.*

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Basics of the Medieval Arabic Medicine: The Vascular Systems in the Canon of Medicine of Avicenna Incorporating a Translation of a Part of the First Book

Zsuzsanna Kutasi

Abstract- Drawing on the knowledge accumulated by the ancient Greek philosophers, medieval Arabic theoretical anatomy seeks to describe the organs, their roles and functions as well as their mutual relationships, embedding this description within a philosophical framework wherever higher or subordinate roles can be ascribed to the particular organs being discussed. According to *Ibn Sīnā* (*Abū 'Alī al-Ḥusayn b. 'Alī*) (Avicenna) (370-428 AH/980-1037 AD), everything in nature is connected with everything else, and the main operator of the body is the immortal divine soul (*rūḥ*). In the process of breathing, a part of the divine soul enters the lungs and then, being mixed with blood, the heart as well, in which the 'pneuma' is formed, which is channeled by the arteries throughout the body. The soul part of the inhaled air (*al-hawā'*) regulates the heart's heat and nourishes it. According to Ibn Sīnā, the heart has three cavities: one on the right side, one on the left side, and the third in the middle, which serves as a kind of blood store. The liver governs the right side, the spleen governs the left one. The heart is located in the middle of the chest and maintains a kind of balance between the two vascular systems. The left side has been exalted because the divine soul comes from the air to the left side of the heart, and from here, it floods the whole body through the arteries. The right side of the body is dedicated to bodily functions like turning food into blood, nourishing the organs, and removing the excess. The right half of the body is operated by the left half through nerves originating from the brain. In the brain, the two sides merge. The source of the veins is the liver, while the arteries arise from the heart.

As part of a close reading of the text, I created a diagram of branches of the blood vessels to facilitate their identification. In many passages of the anatomical description, we only learn that the blood vessel in question branches in three, four, or five directions and travels in a particular order or towards certain body parts. There is always a branch between them, indeed the largest one, and by connecting these largest branches, we get the full path of a given blood vessel from the

beginning to the end. Such as the route *v. cava superior* from the right ventricle (branches in two directions) - *v. brachiocephalica* (units to five) - *v. subclavia* (branches towards 4) - *v. axillaris* (branches towards 3) - *v. basilica* (2 components branch to 4 at the forearm) - *v. mediana cubiti* (branches towards 2) - *v. salvatella* from the heart to fingers.

In some cases, erroneous conclusions can be found in description of Ibn Sīnā wherever he connects blood vessels with different origins. Sometimes Ibn Sīnā begins to describe a route of a blood vessel and then continues to describe another blood vessel as if it were a continuation of the previous one. Alternatively, he also assigns branches belonging to one blood vessel to branches belonging to another blood vessel, such as the *v. jugularis interna*, in describing the units of the *v. jugularis externa*.

Keywords: anatomy, blood-system, Islamic medicine, Avicenna, Ibn Sīnā.

FOREWORD

If a medieval person wished to learn the routes and branches of the blood vessels, the autopsy of a corpse would be indispensable for the collection of such data².

The Arabic term *at-tašrīḥ* for dissection has a double meaning. Medieval Arabic authors used the word in the sense of "anatomy" in reference to an intact body, and also in the sense of "dissection" in reference to the exploration of a corpse. The noun *at-tašrīḥ* comes from the root *š-r-ḥ* (to cut up (flesh)). The ambiguity of the noun itself can be resolved by using the construction *'ilm at-tašrīḥ* (the science of anatomy) to refer to the theoretical science, while the simple noun *tašrīḥ* can be reserved for referring to the practical process of dissection. The solution to this problem of interpretation, which has been a constant theme of Islamic medical literature since the Middle Ages, was provided by *Ḥāğğī Halīfa* and *Muḥammad 'Alī at-Tahānawī* in the 17th and 18th centuries, distinguishing between anatomical knowledge without dissection and understanding requiring dissection. (E. Savage-Smith 1995: 68-69).

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¹ By medieval Arabic medicine we mean the medicine of ancient origin practiced in the Arab Caliphate and its successor states and throughout the medieval Islamic world. In fact, most of the doctors were not Arabs (not even Muslim at first, but Jewish or Christian), but of Syriac (Aramaic), Iranian, Jewish, Turkish, or other descent, who wrote in Arabic, the language of science and culture at the time. Ibn Sīnā was not an Arab either, he was a Persian from today's Uzbekistan.

² „The question of whether human anatomical dissection was ever practiced in medieval Islamic society is not easily or unambiguously answered.” Emilie Savage-Smith, *Attitudes Toward Dissection in Medieval Islam* (1995)

Medieval Arabic theoretical anatomy, based on the knowledge of ancient Greek philosopher-doctors, describes organs, their functions, and functioning, their relationship with each other on a philosophical basis, where there are organs with nobler and subjugated roles. According to *Ibn Sīnā* (*Abū 'Alī al-Ḥusayn b. 'Alī*) (Avicenna) (370-428 AH/980-1037 AD), everything in nature is connected with everything, and the leading operator of the body is the immortal divine soul, ar-rūḥ. In the process of breathing, a part of the divine soul enters the lungs and then, being mixed with blood, the heart as well, in which the 'pneuma'³ is formed, which is channeled by the arteries throughout the body. The soul part of the inhaled air (*al-hawā'*) regulates the heart's heat and nourishes it. (*wa-manfa'at ḥādā al-hawā' al-mu'idd 'an yu'addila birūhihi ḥarārat al-qalbī, wa-'an yamudda ar-rūḥa bil-ḡawharihi alladī huwa 'aḡlabu fī mizāḡihi min ḡayri 'an yakūna al-hawā'u waḥdatan ammā al-mā'u fal-ḡidā'u al-badani wa-ammā al-hawā'u fal-ḡidā'u ar-rūḥi. wa-kulli wāḡid min ḡidā'i-l-badani wa-r-rūḥi ḡismun murakkabun lā basīṭun.*) (The task of this prepared air is to regulate the heat of the heart with the immortal divine soul within it, and to transmit to the divine soul its essence, which is the most definitive part of its constitution (*mizāḡ*), without the air being composed of a single component, but just as water is the substance nourishing the body, so air is the food of the divine soul. Each food of the body and soul is a complex substance and not simple.) (Ibn Sīnā, 1987: Volume 2/Book 3/1122.)

According to Ibn Sīnā, the heart has three cavities: one on the right side, one on the left side, and one in the middle, which serves as a kind of blood store. (*wa-fīhi talāṭa buṭūn baṭnān kaṭīrān wa-baṭnūn kal-waṣṭī⁴, liyakūna lahu mustawda'u ḡidā'in yaḡtadī bihi kaṭīfun qawīyyun yuṣākīlu ḡawharahu wa-ma'dīnu rūḥi yatawalladu fīhi 'an dami laṭīfī.*) (There are three cavities in it, two large and one that seems to be in the middle, to store the food with which to nourish the heart. This food is dense and strong, resembling the essence of the heart. In the heart is the source of the divine soul, which is born in it from the fine blood here.) (Ibn Sīnā, 1987: Volume 2/Book 3/1195.)

Well, even if Ibn Sīnā had dissected the heart himself, it would have been difficult for him to refute the unquestionable claim of Aristotle since antiquity that the

heart has three cavities.⁵ After all, the atria consist not only of those two ears, which are well visible from the outside at the base of the heart; but also of the two small cavities (atria) below them. The smooth-walled lower part of the atria was probably still considered part of the ventricles, and the upper uneven-walled ears of the atria were the natural atria at the time. The smooth lower part of the atriums may be the "middle cavity," the third ventricle.

According to Islam, dissection of the human body in the Middle Ages was not condemned or forbidden, at least as far as the autopsy of the bodies of non-Muslims is concerned. The Muslim principle, derived from the Prophet's hadith, reads: "There are three pillars of knowledge that can be acquired: the authentic recitation of verses from the Qur'an, the study of sayings and traditions attributed to the Prophet Muḥammad (called *ḥadīṭ*), and the knowledge of customary practices of the very early Muslim community (called *sunna*). Everything else that is outside of them is extra to study," and in the Middle Ages, it was modified to say (related that the Prophet said) that there are two forms of science: the science of bodies and the science of religions. (E. Savage-Smith 1995:69-73)

For a long time, the science of bodies, i.e. medicine, was practiced only by Jews and Christians, with Muslims relying on the latter's expertise. This is because Islamic law forbade the mutilation of Muslims' bodies, the breaking of their bones, and the cutting of their bodies before and after death, all of which were allowed for those of other religions. However, it has been recognized that knowledge of anatomy is essential for surgeons (*al-ḡarā'ihīyūn*), phlebotomists (*al-faṣṣādūn*) and cuppers (*al-ḥaḡḡāmūn*),⁶ as they can only do their job well by knowing the exact location of the muscles, blood vessels, and nerves. The dissection of the body alone can only give the performer of autopsy as much knowledge as for the butcher, so it is also essential to acquire prior anatomical knowledge. (E. Savage-Smith 1995: 82-90)

In the 9th century, the Arabs began translating ancient Greek medical manuscripts, including the anatomical works of Aristotle and Galen, based on autopsies, which provided the basis for Arab doctors to

³ During the autopsy of the animals, Diocles identified the two ventricles and the two atria in the heart, but did not dare to oppose the prevailing medical opinion of the age and Aristotle himself, so his discovery remained obscure. (Longrigg 1993: 71)

⁶ The *ḥisba* manuals sharply distinguish between doctors and surgeons. Members of the two groups had to take examinations in different subjects before the market inspector (*ḥāsib*). The task of the market inspector or moral inspector was, among other things, to examine doctors. Phlebotomists and cuppers did not count as doctors, but only as specialists in cupping and vascular cutting. Their prestige was much lower than that of surgeons and bone adjusters: their activities somewhat overlapped those of barbers. (Ormos 1996: 32) *Al-Bīrūnī* (*Abū Rayḡān* 362-440 AH / 973-1050 AD) counts phlebotomists as a separate group of doctors. (Ormos 1996: 35)

³ Pneuma also plays a central role in medieval Arabic physiology and philosophy. There are three types of pneuma (*rūḥ*) that are related to the faculties (forces) that control the body. Within the three main forces, there are several smaller forces in the body. The three main forces are the brain-centered mind faculties *al-quwā an-nafsāniyya*, the liver-centered natural faculties (*al-quwā aṭ-ṭabī'iyya*) and the heart-centered (animate) faculties (*al-quwā al-ḥayawāniyya*). The latter provide the life and cause the heart to contract and relax. (Ullmann 1978: 61)

⁴ The term may refer to a medium-sized ventricle also without indicating its exact location.

write their work. By the 13th century, the leading doctors of the Islamic world were Muslims. But by this time, philosopher-doctors, such as Ibn Sīnā, had been replaced by jurist-doctors such as *Ibn an-Nafīs* (609-687 AH-1213-1288 AD), who was a critic of the great medical canon of Ibn Sīnā (*al-Qānūn fī-ṭibb*).

In about 1025, Ibn Sīnā completed a five-volume medical manual entitled *al-Qānūn fī-ṭibb* (Canon of Medicine), which until the 17th century served as the basis not only for Arabic but also for European medical books. According to him, medicine is a particular class of sciences that includes theoretical and practical sciences. The foundations of his medical creed are the humoral theory and medical ethics of Hippocrates (460-375 B.C.), the theory and anatomy of the four-reason causality⁷ of Aristotle (384-322 B.C.), and theory and practice-based anatomical descriptions of natural faculties of Galen (129-200 B.C.). (Heldreth 2014: 1, 3, 11).

In his book, Ibn Sīnā often begins his statements as 'Galen said,' or 'according to Aristotle.' He quotes the thoughts of one ancient author and another. For example, at Galen, arteries no longer contain air, as Aristotle believes, but a mixture of refined blood and air. (Ibn Sīnā accepts Galen.) Or, for example, as regards the centers of the influential forces, according to Galenos, each faculty has a specific centers in the body, as Ibn Sīnā confesses. According to Aristotle, however, the source of every faculty is the heart. (Ibn Sīnā, Volume 1/Book 1/91, 1987: Volume 1) Ibn Sīnā follows the theoretical system of Galen for the most part.

The anatomy of blood vessels is contained in the fourth chapter of the first volume. The author takes the description of the arteries (*aš-šarāyīn/ al-'urūq aḍ-ḍawārib*) forward, followed by reports of veins (*al-'awrida/ al-'urūq as-sākina*). The reason I do not analyze the descriptions in this particular order is that, in its summary of the veins, the text also reveals the influence of the Galenic idea of the vascular system forming an integral whole that determines the functioning of the organism, this idea serving as a general introduction to the anatomy of the particular arteries.

Ibn Sīnā describes noble (heart, liver, spleen, arteries) and subjugated organs (stomach, intestines, veins), processes assigned to the right and left sides. The organs are philosophically connected. The liver governs the right side, the spleen governs the left one.

⁷ Aristotle developed his teaching on the theory of the four fold causation from Plato's ideology. According to Plato, the material principle alone is not enough to explain the movement, effects (shaping spiritual principle) are also needed. Plato saw the idea as a shaping principle. In Aristotle, the four causes that cause change are the material cause, the active cause, the formal cause, and the ultimate cause. In his theory, he started from the movement (the development of beings) in which matter takes on a new internal form. It performs this shaping of the material while achieving some purpose.

The heart is located in the middle of the chest, lending a kind of balance between the two vascular systems. The left side has been exalted because the divine soul comes from the air, from nature, to the left side of the heart, and from here, it floods the whole body through the arteries.⁸ The right side is dedicated to mundane functions, like turning food into blood and nourishing the organs, and removing excess. The right half of the body is operated by the left half, through the nerves originating from the brain. In the brain, the two sides merge.

Al-Mağūsī (*'Alī b. al-'Abbās*) (Haly Abbas) (died cc. 982-994 AD/ 371-383 AH) mentions a 'third cavity' (*at-tağwīf at-tālīt*) called *manfaḍ* when describing the ventricles of the heart, which Manfred Ullmann translates as 'passage'. (*manfaḍ* -exit, passage, Fonahn, 1922:1935. serial number) (*min at-tağwīf al-ayman ilā at-tağwīf al-aysar manfaḍun yusammihu qawmun tağwīfan tālītan wa-laysa ḍālika kaḍālika.*) (al-Mağūsī 1939: 64).

(The heart has a right and a left ventricle separated by a partition. In this partition there is a passage (*manfaḍh*) which many people (Aristotle is meant) call a 'third ventricle', but this is incorrect.) (Ullmann 1978: 65).

The term *manfaḍ*, which is explained concerning to the ventricles as *tağwīf*, or "cavity" (cavity, Fonahn 1922:3189), is later repeatedly described in the description of al-Mağūsī when it comes to the openings (*fūhāt*) of the great blood vessels entering or exiting the heart. (Here, the meaning of *manfaḍ* is the same as that of *fūha*.) (*ammā al-manfaḍāni al-laḍāni fī at-tağwīf al-aysar fa-aḥaduhumā fūhat al-'irqī aḍ-ḍāribi*). As for the two passage ways in the left ventricle, one of them is the opening of the artery). (al-Mağūsī 1939: 64).

This term (*manfaḍ*) is missing from the heart description of Ibn Sīnā (see Ibn Sīnā 1987: Volume 2/Book 3 1195-1196).

The expression (*min at-tağwīfī-l-aymani ilā at-tağwīfī-l-aysari manfaḍun*) can also be interpreted as meaning that this 'passage' is opening of the truncus pulmonary starting from the right ventricle and leaning towards the left one. The truncus pulmonary leaves the base of the heart below the the aorta opening, beginning from the left ventricle. (Below the aortic arch, is divided into two branches, into the right pulmonary artery and left pulmonary artery and branching out in the lungs.) The opening of the blood vessel thus bends from the right ventricle to the left ventricle. (*fa ammā al-manfaḍu alladī min at-tağwīf al-ayman ilā al-aysar fainnahu min al-ḡānīb al-ayman awsa'u tumma yaduququ qalīlan qalīlan ilā an yantahī ilā al-ḡānīb al-aysar.*) (As for the opening that runs from the right ventricle to the left

⁸ According to al-Mağūsī, the cone-shaped heart surrounded by the lungs also leans to the left side because the 'animal soul' is based here. (Ullmann 1978: 65)

ventricle, it becomes more expansive on the right and narrower as it reaches the left.) (al-Mağūsī 1939:65)

At the base of the pulmonary artery, starting from the right ventricle, is a funnel-like transition, a funnel-like cavity tapering off towards the left and upwards, and a smooth-walled exit from the right ventricle to the pulmonary valve. This cavity is located between the right ventricle and the pulmonary artery. It continues at the level of the coronary sulcus into the pulmonary artery, leaving the heart to the left.

In the heart description of Ibn Sīnā, it is a passage, a channel (*mağrā*) between the two ventricles, which expands as the heart expands and then compresses as the heart elongates. It moves with the heart like the part in the right ventricle from which the pulmonary artery originates.

I used modern anatomical textbooks and online image and video sources to identify the blood vessels in the text of Ibn Sīnā. I wrote the Latin names of the recalled blood vessels in parentheses to translate the Arabic text, and I identified the blood vessels already named in Arabic in the text from the trilingual anatomical dictionary of Adolf Fonahn, called 'Arabic and Latin Anatomical Terminology Chiefly from the Middle Ages.' While reading the text, I made a diagram of the branches of the blood vessels, which made it much easier to identify them. In many places in the anatomical description, we can only know that the blood vessel in question branches in three, four, or five directions and travels in specific directions or towards certain parts of the body. There is always a branch among them, indeed the largest one, and by connecting these largest branches, we get the full path of a given blood vessel from the beginning to the end, such as the route of *superior vena cava* from the right ventricle (branches in two directions) – *brachiocephalic vein* (units towards five) – *subclavian vein* (units towards 4) – *axillary vein* (units towards 3) – *basilic vein* (2 branches branch to 4 at the forearm) – *cubital median vein* (branches towards 2) – *salvatella vein* from the heart to fingers Tracing these routes is not easy because the veins in question run in exactly the opposite direction to the way the medieval text seeks to follow their route, thus making it necessary to constantly rely on knowledge from other types of sources (anatomical textbooks) to establish the successive places by which the particular blood vessel passes. In the Arabic text, the veins start from the liver and from there enter the heart or travel downwards towards the legs. The arteries begin from the heart and travel towards the head and body.

In some cases, erroneous conclusions can be identified in description of Ibn Sīnā wherever he connects blood vessels with different origins: For example, Ibn Sīnā also classifies *vertebral vein* from the ribs as a branch of the *subclavian vein*, but it no longer flows into the vein under the clavicle but directly into the

brachiocephalic vein. Or, for example, the two iliac veins (*v. iliaca communis dextra* and *sinistra*) ten at their branching mix the branches of the inner and outer iliac veins. The first to fourth branches describe the outer branches, the fifth to eighth branches of the internal iliac veins, and then the ninth branch actually again belongs only to the external and the tenth branch to the internal iliac vein.

Sometimes Avicenna begins to describe a blood vessel and then describes another blood vessel as if it were a continuation of the previous blood vessel. Such as in explaining the branches of *internal jugular vein* and *external jugular vein*. It also assigns units belonging to another blood vessel to branches belonging to the blood vessel described.

Description of veins (Ibn Sīnā 1987: Volume 1 / Book 1 84-89)

The quiet blood vessels (*al-'urūq as-sākina*) or veins all start from the liver.⁹ First, two blood vessels grow out of the liver: one on the concave side. The main merit of this blood vessel is the involvement of food in the liver, it is called the *al-bāb* (*v. portae*). The other blood vessel exits the convex side. Its main function is to transport food from the liver to the organs, called the empty vein. (*al-ağwaf*) (*v. cava inferior*).¹⁰

*Anatomy of the portal vein (v. portae)*¹¹:

First, the deep part of the portal vein in the liver is divided into five branches and then gives further smaller units until it reaches the convex surfaces of the liver¹². From here, a vein (*v. cystica*) leads to the

⁹ According to the Galenic vision, the liver is the place where blood is born, the center of venous system and the source of nourishing power.

¹⁰ The visceral surface of the liver (the part facing the viscera) is concave, here is the hepatic portal (*porta hepatis*). This is where the hepatic portal vein (*v. portae*), also known as the varicose vein, enters the liver. The hepatic portal vein is formed behind the head of the pancreas from the confluence of the posterior intestinal vein (*v. mesenterica superior*) and splenic vein (*v. lienalis/ v. splenica*.) Upon reaching the hepatic portal, it usually enters in two branches. The posterior empty vein (*v. cava inferior*) does not originate from the liver but is formed by the confluence of the two common iliac veins (*v. iliaca communis*) at 4th-5th lumbar vertebrae. After collecting the used blood from the legs, pelvic and abdominal organs, and then taking blood from the liver, it draws blood from there. The inferior vena cava is just embedded into the liver, rather than divided into branches in it or becoming part of it. The veins of the liver release branches into it, the blood of which is thus carried on to the heart. Because the empty vein embedded into the liver and leaves it toward the convex side, ancient and medieval observers may have thought that the vein originated in the liver. In fact, all blood vessels (arteries, veins) come out or enter the liver gate.

¹¹ The portal vein carries venous blood corresponding to the odd branches of the abdominal aorta into the liver. (The odd branches of the abdominal aorta travel to the stomach, intestines, pancreas, spleen, and liver.)

¹² The liver has a portal circulation, which means that the vein enters the gland and divides into capillaries like an artery, then collects and leaves as a vein. Within the liver, the hepatic artery (which also arrived through the hepatic portal) to nourish the liver, its capillaries is mixed with capillaries collected by portal vein, then split into branches, and then flowed together into the 3-5 large hepatic veins (*v. hepaticae*) and through them into the inferior vena cava (*v. cava inferior*).

gallbladder. These smaller branches are like the roots of a tree that penetrates deep into their place of origin. The side of the vein that is close to the concavity of the liver splits into eight branches as soon as it separates from the liver. Two of these branches are small; the other six are large¹³.

One of the two small blood vessels is (*v. pancreatico duodenalis inferior*).¹⁴ Travels to the duodenum to attract food, then gives smaller branches, and one of these enters an organ called the pancreas. The other small blood vessel (*v. pylorica*) at the lower part of the stomach and the stomach gate (*al-bawwāb*) (*pylorus*) (where the lower opening of the stomach is) is divided into branches to absorb food.

6/1. One of the six large blood vessels (*v. coronaria ventriculi*)¹⁵ travels to the surface of the stomach to feed the outside of the stomach. The inside of the stomach, on the other hand, benefits from the undigested food that is in it by assimilating it to itself directly, the food becoming thereby the very material of the stomach.

6/2. The second large blood vessel (*v. lienalis*) travels from the six to the spleen to nourish it, but before it comes the spleen, it produces branches, of which the most visible blood vessel turns to the pancreas and then returns to the spleen. Once it reaches the spleen, a chunky unit (*v. gastroepiploica sinistra*) returns to the left side of the stomach to feed it. The branch that penetrates the inside of the spleen reaches the middle, and then a branch starts up and down from it. The upward-moving blood vessel branches off, and a branch gets the upper half of the spleen to feed it. The other department (which goes down) runs the curvature of the stomach and then turns in two directions. One (*v. gastrica sinistra*) travels to the left side of the abdomen to nourish it.¹⁶ The other (*v. gastroepiploica dextra*) plunges into the stomach at the mouth of the stomach (*fam al-ma'ida*) to stimulate the bitter, astringent part of the black bile, from which excess humours flow out. It excites the stomach and this tickling force arouses the appetite.

The downward branch (from inside the spleen) (*v. gastroepiploica sinistra*) also splits in two: one branch branches off in the lower half of the spleen to nourish it. The other branch comes to the omentum (*at-turab*) and units in it to feed it.

6/3. The third large vessel starts on the left of the six (*v. mesenterica inferior*) and branches into the mesentery (*ġadāwil al-urūq*) (~ mesocolon), which surrounds the rectum (*al-ma'ī al-mustaqīm*) (~ mesorectum) (*v. rectalis superior*) to absorb what is in the sediment of the digested food¹⁷.

6/4. The fourth large branch is divided from the six (*v. gastrica dextra*) into hair-thin branches. Some of these branches run to the convex outer half of the stomach, on the right side, where they meet the branch of the vein (*v. lienalis*) originating from the left side of the spleen. Some of these hair-thin branches turn to the right side of the omentum (*at-turab*), branching in it, and encountering the branches coming from here on the left side, from the spleen.

6/5. The fifth branch of the six (*v. mesenterica superior*) is distributed in the blood vessels of the mesenteric (*al-ġadāwil*) (*v. colica dextra / sinistra*),¹⁸ which are around the colon (*al-qūlūn*) to absorb nutrients.

6/6. The sixth branch of the six large vessels (*v. ileocaecalis*)¹⁹ is also divided into branches, and most of the departments pass around the jejunum (*aṣ-ṣā'im*), the others along the small intestine (*al-lafā'if ad-daḡīqa*). around the part that connects to the appendix (*al-a'war*) to extract food from it.

Anatomical description of the branch of the empty vein that moves upwards

First, the base of the empty vein (*v. cava inferior*) is divided into hair-thin branches in the liver itself to attract food from the hair-thin blood vessels of the portal vein (*v. portae*).²⁰ The branches of the empty vein come from the inside the liver, i.e. the convex side of the liver (*ḥadabat al-kabid*). The branches of the portal vein enter the inside of the liver from the concave side of the liver (*taq'ir al-kabid*).²¹

Then the trunk of the empty vein rises from the convex side of the liver and splits into two branches: an ascending branch and a descending branch. The upward branch pierces the diaphragm (*hiġāb*),²²

¹³ The portal vein has four roots: *v. coronaria ventriculi*, *v. mesenterica superior*, *v. mesenterica inferior* and *v. lienalis*. In the description, the other veins are the tributaries of these veins.

¹⁴ One of the branches of the portal vein, *superior mesenteric vein* is a tributary.

¹⁵ A vein passing through the small curvature of the stomach, which is opens into the trunk of the *portal vein*.

¹⁶ The two gastric veins (*v. gastrica sinistra et dextra*) and the two gastroepiploic veins (*v. gastroepiploica sinistra et dextra*) anastomoses with each other and supplies the stomach.

¹⁷ Venous drainage of the lower two-thirds of the rectum is not part of the portal circulation.

¹⁸ The right colic vein (*v. colica dextra*) a branch of superior mesenteric vein (*v. mesenterica superior*) and the left colic vein (*v. colica sinistra*) belongs to the inferior mesenteric (*v. mesenterica inferior*) system. Both transport blood from the colon to the liver.

¹⁹ A branch of superior mesenteric vein (*v. mesenterica superior*).

²⁰ The hepatic veins (*vv. hepaticae*) flow into the inferior venacava. In the description, we can read this in reverse. It is not the empty vein that divides into hairline branches, but the capillary veins flow into the main collecting blood vessel.

²¹ The convex surface (wall surface) of the liver is located towards the diaphragm. The concave surface (visceral) is towards the stomach and intestines. The hepatic veins flow close to the convex side of the inferior vena cava, these may have seemed to the medieval observer as if the empty vein branched towards the liver.

²² The inferior venacava behind the sternum, at the height of the 8th vertebrae (T8) at the *hiatus cavae inferioris* drills through the

penetrates into and is substituted by two other branches, which are divided into sub-branches and transport food to the diaphragm. Then, passing by the pericardium, it sends many large branches, which (eventually) branch out as capillaries and feed it.²³ It is then divided into two units:

A large branch (*v. cava inferior*) reaches the heart and penetrates the right atrial ear (*uḡun al-qalb al-ayman*)²⁴. This blood vessel is the largest of the heart. This one is larger than the others because the other blood vessels are responsible for sucking out the breath (*an-nasīm*), which is used to deliver nutrients. And the nutrient is much fuller than the intake air. It is, therefore necessary that the opening of the blood vessel carrying it be wider and that the blood vessel be larger. This blood vessel, as it enters the heart, is replaced by three valves (*aḡṣiya talāta*)²⁵, the lid of which (*masqafuhā*) moves from the inside outwards and the outside, so that it can draw food from them as the heart expands. Then (the blood vessel) does not return (to its original state) after extension (*al-inbisāt*). Its membranes (its valves) are the most robust.

This vein is replaced by three blood vessels which, passing by the heart, rise from it to the right ventricle and travel towards the lungs, close to the left (ventricle) where the arteries originate.²⁶

diaphragm, with the right phrenic nerve (*n.phrenicus dexter*), and in the company of the right pericardiac phrenic artery (*a. pericardiaco phrenica dextra*).

²³ The inferior venacava after leaving the liver, drills through the diaphragm, then the pericardium and flows into the right atrium. No other veins arrive at this stage. The vein running parallel to it on the rightside, on the otherhand, receives smaller veins from several places, including the pericardium. The azygos vein begins on the rightside of the lumbar vertebrae like ascending lumbarvein, take supveins from several places, then close to the heart flows into superior venacava before it penetrates the right atrium. The description of inferior venacava thus passes into the description of another vein. The unnamed vein that replaces the posterior empty vein in the diaphragm is the azygos vein.

²⁴ The ear (*auricula, sinus venarum cavarum*) is a finger-like extension of the atrium that is separated from the real atrium by a border groove (*sulcus terminalis*). The atrium consists of two parts: a lowers mouth-walled part and an upper uneven-walled part to which the ear is attached. The two ears surround the arteries from the ventricles. During relaxation, it is filled with blood and then empties when it contracts. According to some ancient authors (Aristotle, Galen) and the medieval Arabic idea, the heart has three cavities. In addition to the two large ventricles, which probably included the smooth-walled lower part of the atria, this is the lower atrium, or "small ventricle," that functions as a blood store, the third ventricle of the heart. (Ibn Sīnā 1987: Volume 2 / Book 2 1195)

²⁵ It is a tricuspid valve at the atrial-ventricular boundary (tricuspidal). The lower main collection blood vessel (*v. cava inferior*) has only a rudimentary valve to prevent backflow. And the upper main blood vessel has no valve. The description that "three valves take its place" or "replaced by three valves" (*yatahallafu lahu aḡṣiya talāta*) can be interpreted as meaning that the vein ends here.

²⁶ *Wa hāḡa al-warīdu yaḡlūfu 'inda muḡāḡatal-qalbi 'urūqan talāḡatan taṣīru minhu ilā ar-ri' atī* (Ibn Sīnā 1987: Vol. 2/ Book 2/ 1195 p.) The blood vessels described have no connection to the incoming inferior venacava. One of the blood vessels departing from the right ventricle, the pulmonary artery (*a. pulmonalis*), exits the right ventricle by leaning

1. The wall of one of the vessels (out of three) is bilayer²⁷ like the arteries, called the *vena arteriosa* (arterial-like vein) pulmonary artery. (*al-warīd aš-širyānī / truncus pulmonalis, a. pulmonalis*)²⁸

Its primary merit is that the blood sprayed from it is so infinitely delicate, a delicacy similar to the essence of the lungs. This blood is taken directly from the heart, meaning that it does not mature in the same way as the blood that flows in the *arteria venosa* (*aš-širyān al-warīdī /v. pulmonalis*, (venous artery) (pulmonary vein).²⁹ The secondary merit is that the blood is perfectly worth it.

2. The second branch (*v. Cordis Magna*) of these three travels around the heart and is then sprayed inside the heart to nourish it. It happens (*sinus coronarius*), where the empty vein sinks into the right atrium.

3. The third branch (*v. hemiazygos accessoria*)³⁰ leans to the left in humans, then turns to the fifth vertebrae, rests on it, and gives branches to the lower eight ribs and the muscles and organs close to it.

As for the blood vessel starting from the opening of the empty vein³¹ (*v. cava superior*), having passed three valves³² it rises and reaches the base of the heart, then it leaves the heart and produces hair-thin

toward the left atrium. The blood vessel (2nd) traveling around the heart is the heart's own blood vessel. The largest of the veins of the heart is the *v. Cordis Magna*, running upwards on the anterior surface of the ventricles. In the *sulcus coronarius* it turns to the left and dilates like a coronary sinus and opens into the right atrium. The other veins in the heart either open directly into the atrium or flow into the coronary sinus.

²⁷ Each artery and vein has a three-layered, i.e. triple. The layers of the arteries may not vary in number, only in their complexity depending on how close or far they are from the heart. These layers are not visible to the naked eye. There are no valves in the arteries, this is also true for large collecting blood vessels. The cross section of the arteries is circular and that of the veins is elongated. According to the Arabic description, *al-warīd aš-širyānī* –pulmonary artery bilayer, like the 'real arteries,' *aš-širyān al-warīdī* –pulmonary vein, unlike 'real arteries,' is single-layered. The pulmonary artery opens from the arterial mouth of the right ventricle, the onset of which is conically dilated (*conus arteriosus*). There are three crescent-shaped valves here, just like at the left ventricular artery, where the aorta exits the heart (*bulbus aortae*). In this feature, the two blood vessels is similar.

²⁸ Fonahn, serial number 3343. In the description of al-Maḡūsī this blood vessel is called *al-'irq aš-širyānī*.

²⁹ Fonahn, serial number 2988. In the description of al-Maḡūsī this blood vessel is called *aš-širyān al-'irqī*.

³⁰ Only one bloodvessel exits the right ventricle (*truncus pulmonalis*), which divides to the right half and lefthalf of the lungs (*a. pulmonaris dextra et sinistra*), and three blood vessels enter (*vena cava inferior, vena cava superior, v. Cordis Magna*). Therefore, I think that the third blood vessel described here does not actually exit the ventricle, but from behind the heart, and goes down from the 1st rib to the 7th rib, past the spinal vertebrae, and then passes to the rightside at the 8th vertebra and flow into the azygos vein. Its collection area is the posterior body wall, posterior pericardial surface, esophagus, and lungroots (*vv. bronchiales*).

³¹ The medieval author probably considers the superior vena cava (which actually arrives from above, from the lungs) departing the right atrium to be the continuation of the inferior vena cava ending here.

³² Right venous mouth, tricuspid valve.

branches (*šū'ab ša'riya*) at the upper parts of the gator plate (mediastinum) deviding the chest in two (*fī a'ālī al-ağšīya al-munaşşifa lil-şadri*), in the upper parts of the pericardium (*fī a'ālī al-ğilāfi*), and in the soft flesh called thymus (*tawṭa*) (*v. thyroidea*).³³ Then, close to the clavicle (*at-tarqūwa*), it adds two branches diagonally in the direction of the clavicle, two sides apart (*v. brachiocephalica dextra et sinistra*).³⁴ Both components are divided into two units (*v. subclavia* and *v. jugularis interna*).³⁵ One branch (*v. subclavia dextra et sinistra*) passes downward to the right and left of the sternum until it reaches the larynx (*hanğara*) (*v. jugularis anterior*).³⁶ Going down, it adds branches to the muscles between the ribs (*v. vertebralis*).³⁷ Their openings meet the openings in the blood vessels scattered throughout the muscles.³⁸ A group of these leaves (*barazat minhā*) towards the muscle outside the chest (branches of *v. axillaris*).³⁹

Once the blood vessel (a branch of the internal jugular vein) has supplied the larynx (with nutrients), a group breaks out of it towards the shoulder, forming and moving (muscle)⁴⁰ and gives branches in it (*v. thoracoacromialis*).⁴¹ A group travels downward under

the straight abdominal muscle⁴² and units into it (*v. epigastrica*).⁴³ The ends of the blood vessels are connected to the ascending branches of the lumbar vein (*al-warīd al-'ağzī*) (*v. iliaca communis*).⁴⁴

The remaining branches of both pairs (right and left) split into five at the clavicle⁴⁵:

1. One branch continues in the chest and nourishes the first four ribs. (*v. subscapularis*)
2. The second branch supplies the area around the two shoulders.
3. The third branch travels to and feeds the deep-lying muscle of the neck.
4. The fourth branch penetrates the cavities between the upper six vertebrae of the neck and reaches the head through them. (*v. intervertebralis*)
5. The fifth branch is the largest of all and leads to the armpit from all directions (*v. subclavia*) and then splits into four branches:
 - 5.1 The first branches into a muscle in the sternum, one of the blood vessels needed to move the shoulder joint.
 - 5.2 The second branch continues to branch into the soft flesh (*al-laḥm ar-raḥū*) and membranes (*aş-şifāqāt*) of the armpit. (*v. axillaris*)
 - 5.3 The third branch (*v. thoracoepigastrica*) descends from the side of the chest to the delicate lower abdomen (*marāq*).
 - 5.4 The fourth branch is the largest of the four and is divided into three branches⁴⁶:
 - 5.4.1 A branch branches off in the muscle in the concavity of the shoulder. (*v. cephalica*)
 - 5.4.2 The second branch travels in the large muscle at the armpit. (*v. brachialis*)

³³ The thyreoid vein (*v. thyreoida*) which collects venous blood from the thymus, branch of brachiocephalic vein.

³⁴ One of the tribes of the superior vena cava coming from above to the right atrium is the right brachiocephalic vein, which, together with its left counter part, can take up branches mainly from the pericardium, the thymus, and from the deep of neck and from the spine (*v. vertebralis*).

³⁵ The brachiocephalic vein collects branches from both sides. From the clavicle to the subclavian vein, from the brain to the internal jugular vein.

³⁶ The anterior jugular vein flows into the subclavian vein.

³⁷ The subclavian vein (vein under the clavicle) is made up of three branches: *v. jugularis anterior* from the inside of the neck (the area of the larynx), *v. jugularis externa* from the outer surface of the neck, and *v. thoracoacromialis* comes from the shoulder girdle. From the ribs the vertebral vein, another branch of brachiocephalic vein collects blood.

³⁸ According to the ancient idea (Erasistratos), blood vessels are connected to each other through openings at their ends. These openings are usually closed, they only open in case of over production of fluids, inflammation, fever. This allows blood to pass from the veins to the arteries. (Brain, 1986: 125.) This may not be the case in the Arabic text, but simply describes the tangled web of thins mall blood vessels in this way.

³⁹ The axillary vein (*v. axillaris*) flows into the vein under the clavicle (*v. subclavia*) and collects superficial veins in the chest, abdomen, and upper extremities. The axillary vein passes below the small pectoralis muscle (*m. pectoralis minor*) from the axillary trench. The axillary vein progresses at the lower edge of the major pectoralis muscles till asv. *brachiales*. The 'muscle outside the chest' is the deltoid muscle (*musculus deltoideus*), one of the muscles of the shoulder, below which the cephalic vein arrives from the forearm in the axillary vein.

⁴⁰ The muscles that move the shoulder and upper limbs include the back muscles: *m. pectoralis major* (large pectoral muscle), *m. pectoralis minor* (small pectoral muscle), *m. subclavius* (muscle under the clavicle), *m. serratus anterior* (anterior saw muscle).

⁴¹ *v. thoracoacromialis* (chest-shoulder vein) flows into the subclavian vein. Its collection area is *m. deltoideus*, *m. serratus anterior* and the shoulder joint.

⁴² Of the abdominal muscles, the straight abdominal muscle (*rectus abdominis*) runs down bothsides of the midline of the abdominal wall. The muscles originate from the cartilage of the ribs 5th, 6th, 7th at the height of the sternum and adhere gradually to the pubicbone, tapering downwards from the navel.

⁴³ Both the superficial and deepveins of the abdominal wall, the accompanying veins of the epigastric arteries (*vv. epigastricae*) are led partially upward in the axillary artery (*v. thoracoepigastrica*) and towards the subclavian vein, partly down to the femoral vein and deeper into the external iliacvein (*v. epigastrica inferior*).

⁴⁴ The azygos vein take up lumbar segmental veins from the rightside of the vertebral bodies of the lumbar spine. Then continuing upwards on the rightside of the spine, thev. *Azygos* picks up its left pair at the height of the 7th vertebra, thev. *hemiazygos*, (and *v. hemiazygos accessoria*, also on the left) and then the superior vena cava flows into the superior and through it into the right atrium of the heart. Although the veins in the lumbar area are collected by the lower empty vein (*v. cava inferior*), certain areas are not reached by this vein, such as the lumbar areas of the posterior trunkwall, which are collected by the *v. azygos* system.

⁴⁵ It is a branch of *v. brachiocephalica dextra* and *sinistra* coming to the *v. cava superior* from bothsides (right-left). The largest of the five branches is the *v. subclavia*. The other four branches are veins from the collection area of the *v. brachiocephalica*: from the area of the head, neck, thyroid gland, thymus, esophagus, pericardium, upper extremities and part of the chest.

⁴⁶ This is still th exillary vein.

5.4.3 The third branch is the largest of the three, moving from the upper arm towards the hand, called *al-ibtī* (*v. basilica*).⁴⁷

The blood vessel that remains from the first branch (the other branch of the *v. brachiocephalica*) and one of the branches (*v. subclavia*) gives this many branch that moves upwards towards the neck.⁴⁸ However, before it penetrates deep into the neck, it splits into two branches. One is the external jugular vein (*al-widāğ az-zāhir*) (*v. jugularis externa*)⁴⁹ and the other is the internal jugular vein (*al-widāğ al-ğā'ir*) (*v. jugularis interna*).⁵⁰ The outer jugular vein, as it rises from the clavicle, splits into two branches:

1. One branch, as soon as it separates (from the main branch), turns forward and to the side. (*v. jugularis externa anterior*)
2. The other branch first turns forward and then moves down. It then grows, becoming visible a second time at the clavicle. It bypasses the collarbone and then rises and becomes visible on the neck until it reaches the first branch and merges with it. (*v. jugularis externa posterior*)

The two of them will become the known external jugular vein. Before the two join, two branches separate from it: One turns to the center, and then, at the meeting point of the two clavicles, inside, the two branches meet. The other branch moves diagonally around the neck visibly and does not meet any other blood vessels after that.

From this pair of blood vessels (an internal, and external jugular vein) many veins branch out like cobwebs that can no longer be distinguished (*tafūt al-ḥass*). From the second pair of blood vessels (external jugular vein) three identifiable veins separate that are significant. The rest cannot be explored. One of these identifiable veins extends to the shoulder and is called *al-katīf / al-kitfī* (*v. cephalica antebrachii*).⁵¹ From there continues the *al-qīfāl* (*v. cephalica*)⁵² and two more veins on either side of it (*v. brachialis* and *v. basilica*) that accompany it to the tip of the shoulder (*ra's al-katīf*). One of them closes before reaching the end of the shoulder, but gives branches towards the direction of the shoulder. Of the two blood vessels, the one that passes in the anterior part (*al-mutaqaddim*) reaches the apex of

the shoulder at the top of the upper arm (*ilā ra's al-aḍud*) and branches there. The *al-katīf / al-kitfī* (*v. cephalica*) is reached by both blood vessels together at the back of the hand.

The external jugular vein, as soon as it separates into branches, splits again in two, and one of these latter penetrates deep into the upper jaw (*v. maxillaris*) in the form of thin branches. The other unit is much larger and branches off at the jawbone (*v. linguofacialis*, *v. facialis*). Both blood vessels give components around the tongue and outside the jaw muscles. The branch in the upper jaw appears close to the surface and units in the head and ear areas.⁵³

The internal jugular vein (*al-widāğ al-ğā'ir*) (*v. jugularis interna*) passes by the esophagus and rises straight next to it.⁵⁴ In its way, it gives branches⁵⁵ that mix with the branches coming from the external jugular vein (*al-widāğ az-zāhir*) (*v. jugularis externa*). Each vessel is subdivided into other branches at the esophagus (*al-marī*) and the larynx (*al-ḥanğara*) (*v. pharyngealis*) and all deep-seated muscles. The end of the blood vessels penetrates the end of the lambda suture (*ad-dar al-lāmī*)⁵⁶ (*sutura lambdoidea*) of the skull,⁵⁷ where branches are given, and some of these branches are distributed between the first and second vertebrae.⁵⁸ Of these, a hair-thin blood vessel reaches the joint between the head and the neck (*v. cervicalis transversalis*), and from there the blood vessels start toward the membrane covering the skull (*v. jugularis posterior externa*). The blood vessels reach the junction of the two skull bones and there they dig into the inside

⁵³ The facial vein (*v. facialis*) is the main superficial drainage vein of the face. It forms around the inner corner of the eye (here is *thev. angularis*) from the smaller veins of the forehead (*v. trochlearis superior*), the back of the nose (*v. orbitalis superior*), the eyelids and the anterior cavity. The main drainage vein of the deeper layers of the face is *thev. retromandibularis*. It develops on the innerside of the parotid gland in the trench below the temporal bone, at the confluence of *v. temporalis superficialis* and *v. maxillaris*. Its main collection area is the area around the deep mastication muscles. Going downwards like *v. retromandibularis lateralis*, flow with the facial vein and as *v. facialis communis* flows in internal jugular vein.

⁵⁴ The internal jugular vein originates in the posterior part of the *foramen jugulare* based on the skull. A broad, sac-like vein that travels almost vertically down the neck in a common connective tissues sheath with the internal carotid artery (*a. carotis interna*) and with the vagus nerve (*nervus vagus*). With a lower dilation (*bulbus venae jugularis inferior*) behind the upper part of the clavicle (in the *angulus venosus*), flows to the subclavian vein.

⁵⁵ On the one hand, the brain transports venous blood through the foramen jugulare, and on the other hand, it collects the venous branches of the hard meninges, inner ear, pharynx, larynx, by *v. retromandibularis anterior* and by *v. facialis communis*.

⁵⁶ Fonahn, serial numbers 1110, 1111: 'derez- sutura' The Arabic *daraza, yadruzu, darzun* means 'sew'.

⁵⁷ Here is the opening (*foramen jugulare*) from which the internal jugular vein exits the skull.

⁵⁸ The internal jugular vein flows into the subclavian vein. Its collection area does not cover the area behind the ear and the nape of the neck, only the deeper areas of the whole head and neck. That is, the branches mentioned in the Arabic text belong to the external jugular vein.

⁴⁷ Fonahn, serial number 1612.

⁴⁸ This branch is not moving upwards, but another: *v. jugularis externa*.

⁴⁹ Fonahn, serial number 3585.

⁵⁰ Fonahn, serial number 3586. Arriving in the right atrium two large bloodvessels flow into the superior vena cava, one from the rightside (*v. brachiocephalica dextra*) and the other from the leftside (*v. brachiocephalica sinistra*). Both branches are connected by two large bloodvessels from above: one is the vein under the collarbone (*v. subclavia*) and the other is the internal jugular vein (*v. jugularis interna*). The external jugular vein (*v. jugularis externa*) arrives at first into the internal jugular vein or into the subclavian vein and only then into the brachiocephalic vein.

⁵¹ Fonahn, serial number 1764.

⁵² Fonahn, serial number 2710.

of the head. The other branches also penetrate deep into the head at the end of the lambda suture, and then additional components are inserted into the two meninges (*ġiṣā'iyyā ad-dimāġ*) to nourish them and to connect the hard meninges (*al-ġiṣā' aṣ-ṣulb*) (dura mater) with what is around and above it.⁵⁹ He then rises to feed the membrane covering the skull (*al-ḥiġāb al-muġallil lil-qihf*). It then travels down from the soft meninges (*al-ġiṣā' ar-raḳīq*) to the brain (*ad-dimāġ*) and branches into it like the arteries. The blood collected from the 'thick' (hard) meninges (*aṣ-ṣifāq aṭ-ṭahīn*) is taken to a spacious, open place (*al-faḳā'*) where the blood contains. From here, it branches off between the two meninges. This big place is called *ma'ṣara* (torcular Herophili).⁶⁰ As the capillaries approach the central ventricle of the brain (*al-baṭn al-awsaṭ min ad-dimāġ*) (*ventriculus tertius*), they necessarily become larger blood vessels and are absorbed in the torcular Herophili.⁶¹ Flights branch off from it and then extend further from the central ventricle of the brain to the two anterior chambers⁶² (*al-baṭnān al-muqaddimān*) (*ventriculus lateralis*). The veins here meet the ascending arteries and form a network known as *aṣ-ṣabaka al-maṣīmīya* (*plexus chorioideus*, vascular plexus in the ventricles).⁶³

⁵⁹ The hard meninges (*dura mater*) are fibrous, dense connective tissue discs with endothelial-lined dura ducts (sinuses) in which venous blood flows from the brain. This is the outer layer of the brain, under which a layer of loose connective tissue covers the surface of the brain like a „cobweb“ (*arachnoidea*). This layer contains no blood vessels. The third meninges (*pia mater*) lie snugly against the surface of the brain, filling all the fissures and ditches (sulcus/sulci), rich in blood vessels. Together with the arachnoidea, they form the soft meninges (*leptomeninx*).

⁶⁰ Fonahn, serial number 1961. Torcular Herophili is the confluence of venous sinuses at the protruding part nape of the skull. (Connecting point of lateral, sagittal, and occipital venous sinuses.)

⁶¹ The internal cerebral veins flow from the right and left into the large cerebral vein (*v. cerebri magna*, Galen's vein) at the upper wall of the 3rd brain chamber. This vein flows into the *sinus rectus* and then to the connecting point of the cerebral venous sinuses (torcular Herophili). From here it enters a venous sinus (*sinus sigmoideus*) that bends in an "s" shape, from which the blood will be removed from the skull by the internal jugular vein.

⁶² The lateral ventricles have front, rear and lower horns. Here in the text we are only talking about the front horn. (A more detailed description of the anatomy of the brain can be found in another chapter: Ibn Sīnā 1987: Volume 2 / Book 3. 807 p.) The two lateral ventricles and the third ventricle between them, are located in the cerebellum. The anterior horn of the lateral ventricle is in the frontal lobe, the posterior horn is in the occipital lobe, and the lower horn is in the temporal lobe. In a horseshoe shape, they surround the third ventricle between the two hemispheres, a narrow cavity between the thalamus and the hypothalamus. Each of the lateral ventricle produces liquor. From the lateral ventricles, the liquor enters the third ventricle, and from there to the fourth one through the ducts and openings between the ventricles.

⁶³ Fonahn, serial number 2957.

*Anatomy of the veins in the hands*⁶⁴

As for *al-kitfī* (*al-katīfī*) (*v. cephalica*), it is also known as *al-qīfāl* (*v. cephalica*). The first branches in the skin and at the back of the upper arm (*al-'adud*) are separated as it passes parallel to the upper arm. It then splits into three parts near the elbow joint:

1. One is the *ḥabl aḍ-ḍirā'* (a vein running upwards on the lateral side of the upper arm, *v. cephalica pollicis*)⁶⁵ which extends to the surface of the radius (*az-zand al-'a'la'*)⁶⁶ and then the lateral - *waḥṣī* turns sideways in the direction of the bulging (*ḥadabat az-zand al-asfal*).⁶⁷ It is divided into branches at the bottom of the lateral parts of the wrist (*ar-rusġ*).
2. The second branch moves towards the elbow bend (*m'aṭīf al-mirfaq*) on the outside of the forearm (*as-sā'id*) and mixes with the extension from *al-ibṭī* (*v. basilica*)⁶⁸.

Two of them will be *al-akḥal* (*v. nigra*, *v. mediana cubiti*)⁶⁹

3. The third branch enters (into the upper arm) and there it mixes with the branch also from the *al-ibṭī* (*v. basilica*).

As for the *al-ibṭī* (*v. basilica*)⁷⁰, it first gives branches that dig into the muscle [the muscle of the upper arm], then branch out into it and end there, except for one that reaches the forearm (*as-sā'id*). As in *v. basilica* comes the area around the elbow joint; splits in two⁷¹:

1. One of the two branches penetrates deeply and connects to the deep branch of the *al-qīfāl* (*v. cephalica*)⁷² on the left side, and then runs next to it for some length before separating again. One of them goes down to the inner side (*al-insīy*) (*medialis*) until it reaches the little finger (*al-ḥinṣīr*), the ring finger (*al-binṣīr*) and half of the middle finger (*al-wusta*). The other branch passes upward and is separated into several parts in the back of the hand.

⁶⁴ The hands are palms forward next to the body. In this baseline, the two bones that makeup the forearm are parallel to each other, so that the radius is on the lateral side, while the ulna is on the medial side (supinatio: parallel position). If the hand is palm backwards, the two bones are transverse to each other (pronatio). Knowledge of this is required to interpret and track the description of blood vessels.

⁶⁵ Fonahn, serial number 1488.

⁶⁶ Fonahn, serial number 3683.

⁶⁷ Fonahn, serial number 3684.

⁶⁸ *v. basilica*: basilic vein, medial skin vein of upper limb

⁶⁹ Between the cephalic vein and the basilic vein there are thick anastomoses in the area of the elbow region, which are superficially located, one of these connecting blood vessels being the *v. mediana cubiti*. Fonahn, serial number 100. (*vena nigra*, black vein)

⁷⁰ Fonahn, serial number 1612.

⁷¹ *v. basilica*: collects the capillaries of the skin veins of the back of the hand in the ulnar direction.

⁷² *v. cephalica*: cephalic vein, the lateral vein of the upperlimb, collecting the skinveins of the back in the radial direction.

2. The other extension from the two branches of the basilic vein split into four units at the forearm.⁷³
 - 2.1 One of its units divides from the lower parts of the forearm to the wrist.
 - 2.2 The second unit branches over the first extension, just like the first unit.
 - 2.3 The third branch is distributed in the middle of the forearm in this way.
 - 2.4 The fourth branch is the largest, and it is the one that becomes visible. It goes upwards and sends branches to components of *al-qīfāl* (v. *cephalica*) and from them will be the branch of *al-akḥal* (v. *mediana cubiti*). Which is not related to them, that remains of the original unit of the *al-bāsiliq* (v. *basilica*). This blood vessel penetrates into the deep again.

The *al-akḥal* (v. *mediana cubiti*) begins on the inner side (*al-insīy*) (*medial*), then downwards on the forearm (*az-zand al-a'īā*) (on the radius) and then turns in the lateral direction (*'alā al-wahṣī*) and gives two branches, similar to the shape of the Greek letter lambda. Its upper part is placed on the side of the radius and runs to the wrist, then passes through the back of the thumb (*al-ibḥām*), then runs between it and the forefinger (*as-sabāba*) and the index finger. The lower part turns in the direction of the ulna (*ilā taraf az-zand al-asfal*) and divides into three branches:

1. One of the departments turns towards the place between the middle finger and the index finger and connects with the branches of the blood vessel, which return to the index finger from the upper part and merge with it as one blood vessel.
2. The second unit is called *al-uslīm* (*al-usaylim*) (v. *salvatella*)⁷⁴ which branches off between the middle (*al-wuṣṭā*) and the ring finger (*al-binṣir*).
3. The third extension extends between the ring finger (*al-binṣir*) and the little finger (*al-ḥinṣir*).

This part concludes the description of the upwardly extending branch of the empty vein, which is the more minor part of the empty vein.

Anatomy of the downward empty vein (al-aḡwaf an-nāzil)

The first downward part of the empty vein is the one that leaves the liver. Before it rests on the spinal column, it becomes hair-thin branches⁷⁵ that progress to the layers of the right kidney (*lafā'if al-kulya*) (v. *renalis dextra*). It will branch out into it and the parts around it to nourish them. After this, a thick blood vessel separates

into the left kidney (v. *renalis sinistra*), which is also divided into hair-thin branches in the sheath of the left kidney (*lafā'if al-kulya al-yusrā*), and in the parts close to it to nourish them. Then two large blood vessels, called the *af-tālī'ūn*⁷⁶ (v. *renales*), separate from it [from the downward empty vein] and travel to the two kidneys to clean the watery part of the blood (*mā'iyat ad-dam*). The kidneys extract their contents (*ḡidā'uhā*) from the two kidney veins, the aqueous part of the blood, and one blood vessel from the left blood vessel goes to the left testis in men and the left ovary in women.⁷⁷

Like the arteries, the veins travel similarly, branching out, in the testicles and ovaries. The blood vessel that goes to the left kidney always 'absorbs' its contents from the left renal vein (*ya'ḥuḍu 'abbatan minhu*). And the blood vessel that goes to the right kidney gets its food from the right kidney vein. In the kidneys, there is a duct in which the sperm (*al-minā*)⁷⁸ get mature. The sperm is originally red, given its white colour only by the thickness and roundness of the wall of the blood vessels in the conduit and by the effect of a substance originating in the spinal column.⁷⁹ Much of this blood vessel is absorbed in the penis and cervix and, in places already mentioned in the description of the arteries and renal veins. A branch rests against the empty vein along the spine and starts down. It gives a branch to each vertebra, penetrates and branches into the muscle at the vertebrae, -veins branch toward the two hips and end at the abdominal muscles. There are blood vessels that travel into the openings between the

⁷⁶ Fonahn, serial number 3206.

⁷⁷ The testicular vein leaves the testis through the seminal cord and from the left testis flows into the renal vein, while from the right testis joins the inferior vena cava. Around the middle of *them. psoas major*, the *ureter* intersects obliquely in men with the testicular artery (*a. testicularis*), in women the ovarian artery (*a. ovarica*) and the surrounding braided veins (*plexus pampiniiformis*).

⁷⁸ Sperm are produced by germ cells in the inner half of the testis and mature in the epididymis. The *funiculus spermaticus* (seminal duct) enters the pelvis through the groin as part of a seminal cord containing blood vessels and nerves. Its widened section extends to the bottom of the bladder and then merges between the bladder and the urethra on the inside of these seminal vesicles with its outlet tube.

⁷⁹ The duct in the kidney is the *ureter*, which has a part of the abdomen (*pars abdominalis*) and a pelvis (*pars pelvina*). In the abdominal section, the urethra intersects with the internal spermatic artery (*a. spermatic ainterna*). Under the paired renal artery, the paired internal spermatic artery (in men) and the paired ovarian artery (in women) originates from the abdominal aorta. It crosses the external iliac artery (*a. iliaca externa*) at the border of *pelvis minor* and *pelvis major*. In men, the ureter crosses the duct of semen in the pelvis minor, in women with uterine artery (*a. uterina*). Arteries are accompanied by veins everywhere. Because of this, due to the myriad crossings back and forth, it may have seemed to the medieval observer that the formation of the sperms had something to do with the kidneys and the leads from it. In the renal gate, the renal vein (v. *renalis*), the renal artery (*a. renalis*) and ureter they are behind each other. The inferior vena cava travels parallel to the spine, into the inferior vena cava arrives v. *renalis* after collecting smaller veins collected from the renal filter system. The image of sperm changing from red to white was probably the result of the entanglement of blood vessels and the urethra.

⁷³ In the elbow bend the basilic vein on 2 branches, the cephalic vein splits into 3 branches. In the forearm, the arteries are accompanied by 2-2 veins, called 'accompanying veins.'

⁷⁴ Fonahn, serial number 3630. The *salvatella* vein passes between the 4th and 5th hand bones.

⁷⁵ They do not branch out from the liver, but belong to the visceral branches of inferior vena cava. The under the liver part of the inferior vena cava contacts the medial edge of the right kidney and the right adrenal gland.

vertebrae to the spinal cord. When (the empty vein) reaches the last vertebra,⁸⁰ it turns in two directions: they turn to the right (*v. iliaca communis dextra*) and to the left (*v. iliaca communis sinistra*), and then both move in the direction of the thighs. Both give branches to ten before reaching the liver.

1. One branch (*v. iliaca externa*) moves towards the lumbar region (*al-matnān*) (*regio lumbalis*).
2. The second branch (*v. iliaca interna*) is hair-thin and extends to the lower abdomen.
3. The third branch (branch of *v. iliaca externa*) is divided the muscle of the sacrum (*os sacrum*)
4. The fourth branch (branch of *v. iliaca externa*) is divided into the pharyngeal muscle (*'aḍl al-maq'ada*) and the outer half of the tail (*zāhir al-'aḡuz*).
5. The fifth branch (*plexus uterovaginalis*)⁸¹ in women turns towards and branches in and around the cervix (*'unuq al-rahm*) and in the bladder (*al-matāna*) (*plexus vesicalis*). The vessel that leads straight to the bladder splits into two parts: one branches into the bladder, and the other turns toward the neck (*cervix*). This branch multiplies in the penis in men and is divided into a few components in women. Of the blood vessels that extend laterally to the uterus, some branches run upward to the breasts to connect them to the uterus (*v. epigastrica inferior*).⁸²
6. The sixth branch (*plexus pudendalis*) moves towards the muscles of the pubic bones (*'azm al-'āna*) (*ossa pubis*).
7. The seventh branch moves upward in the straight abdominal muscle. These blood vessels (*v. epigastricae*) are connected to the ends of the blood vessels that descend from the chest towards the lower delicate part of the abdomen (*marāq al-baṭn*). From the origin of these descending blood vessels (*min aṣl hādīhi al-'urūq*) are the blood vessels that reach the uterus in women (*plexus uterovaginalis*).
8. The eighth branch (*plexus panpiniiformis*) extends to the genitals (*al-qubl*) in both men and women.

⁸⁰ This is not the end of the spine, only the end of the vertebrae. The end of the dorsal vertebrae is in the lumbar region 4th-5th at the vertebrae, at the height of the *articulatio sacroiliaca*. Coming from the direction of the two hips where *v. iliaca communis dextra* and *sinistra* meet and flow here to inferior vena cava. Here in the description, the blood vessels proceed in reverse, as it is the medieval idea that the veins and not the arteries are the ones that deliver nutrients to the organs.

⁸¹ This branch already belongs to the internal iliac vein (*v. iliaca interna* or also known as *v. hypogastrica*). The *hypogastric vein* transports blood from the organs of the pelvis. There are well-developed venous braids around the organs here: 1. *Plexus haemorrhoidalis* (around the rectum), 2. *Plexus vesicalis* (around the bladder), 3. *Plexus pudendalis* (around the pubic bone, bladder and urethra), 4. *Plexus uterovaginalis* (around the uterus and vagina).

⁸² *Inferior epigastric vein* branch of *external iliac vein*.

9. The ninth branch (*v. femoralis*) spans and adds units to the inner half of the thigh.
10. The tenth branch moves visibly from the urethra (*al-ḥālib*) towards the hips (*ilā-l-ḥāṣiratayni*) (lumbar region, *regio lumbalis*) (contact with the vascular descending vessels (*v. epigastricae*)) with its end branches. Of the many small vessels, this is the one which eventually becomes a larger vessel (*v. testicularis*) and end in the testicles (*'aḍl al-untayayn*).⁸³

The blood vessels that do not collect in the large blood vessel leading to the testicles go to the thighs and give larger or smaller branches. One of these branches goes to the muscle on the anterior surface of the thigh, and another branch deepens in the muscle (medial side) of the lower and inner halves of the thigh (*ft 'aḍl asfal al-fahid wa-insiyyihi*). Many small branches branch off deep in the thigh, which remains beyond these, becoming below the knee joint into three branches:

1. The lateral branch of these extends from the fibula (*al-qaṣabat aṣ-ṣuḡrā*) to the ankle joint (*maṣ'il al-ka'ab*).
2. The middle branch moves downward in the knee flexion and leaves in the muscle's units inner half of the leg. Two units branch off, one of which penetrates deep into the leg. The other of the two tibias reaches the anterior half of the tibia and mixes with the extensions of the lateral unit.
3. The third branch, the *al-insīy* (*internalis, medialis*), turns to the veined side of the leg (*al-mawḍi' al-mu'arraḡ*) and then goes down to the ankle on the convex side of the tibia (*aṭ-ṭaraf al-muḥaddab min al-qaṣaba al-'uzmā / al-kubrā*). Then it moves forward from the middle, this is the *aṣ-ṣāfin* (*v. saphena*)⁸⁴

⁸³ The testicular vein leaves the testicle in the seminal cord. Here in the description it goes exactly the other way around. On the right it flows into the inferior vena cava, on the left into the renal vein.

⁸⁴ The Greek and Arabic meanings of the name of the rose vein (*v. saphena*) differ significantly. While the meaning of the vein that Celsus still called the ankle vein (*vena ad malleolos*) was 'clear, visible,' the Arabic word means 'hidden.' This is because, in contrast to other skin veins in the human body, which are well visible through the skin in a healthy state, the much of saphenous vein, which runs from the ankle to the thigh, cannot be seen, it remains hidden. However, it appears behind the inner ankle. It was also used for blood sampling in the Middle Ages. The rose vein used to be called 'tünér' in Hungarian means 'disappearing vein.' His German name also reveals a lot about it: *Frauenader* (female vein) as women more often suffered from dilation of this blood vessel (varicositas, network varicose veins), *Scheinader* (false artery), or *Rosenader* (rose vein). The Arabic participle figure *ṣāfin* also means a horse, that stands on three legs, and bends one of its front legs. (Lane 1872: 1703). This condition contradicts the resting position of horses, in which one of their hind hooves is placed on their rim, and thus rested, since most of their body weight is carried by the front legs. While grazing, the horse can bend one of its front legs, thus he stands on three legs or, as Lane writes, the nomads can tie one of the front legs of the horse to its forearms to prevent them from wandering far away.

These three branches branch to four directions: Two lateral units start to the foot from the direction of the fibula (*al-qaṣabat aṣ-ṣuḡrā*) and two units from the inside: one to the upper part of the foot and the little toe (*al-hinšir*) branches off. The second department is the one that mixes with the side units that branched off from the previously mentioned internal branch (*al-insīy*). The latter two components off at the lower parts of the foot.

Description of the arteries (Ibn Sīnā 1987: Volume 1. / Book 1. 81-84 p.)

The 'pulsating blood vessels' (*al-'urūq aḍ-ḍawārib*), in other words, the arteries (*aṣ-ṣarāyīn*), were created to be bilayered⁸⁵ (*ḍāt aṣ-ṣifāqayn*). Of the two layers, the interior is more solid because it is the meeting point of the two layers. The essential nature of the divine soul (*ar-rūḥ*) (carried by the arteries) is its strong movement. The purpose of this is to protect and preserve its essence, to strengthen its keeping vessel.

The source of the arteries from the two cavities of the heart (*min taḡwīfay al-qalbi*) is the left cavity (*at-taḡwīf al-'aysar*) (*ventriculus sinister cordis*).⁸⁶ Because the right hole is closer to the liver, it is necessarily responsible for attracting and processing food.⁸⁷

*Anatomy of the venous artery (aṣ-ṣiryān al-warīdī) (arteria venosa / pulmonary vein)*⁸⁸

First, two arteries exit the left ventricle:

1. One of these ends in the lungs and branches off in it to absorb the breath and to carry from the heart to the lungs the blood that feeds the latter. Because the heart is the mediator of nourishment for the lungs, blood comes from the heart to the lungs. The origin of this blood vessel is in the most delicate part of the heart,⁸⁹ where the veins that enter it

⁸⁵ The wall of each blood vessel (artery, vein) consists of three layers. The structure of the layers of the arteries varies, (not their number), depending on how close or far they are from the heart. In the description these are probably not essential layers, as they are not visible to the naked eye.

⁸⁶ Fonahn, serial number 3197.

⁸⁷ Here food becomes the substance of the heart. This is because the third digestion takes place in the organs, during which the food that comes in the blood, becomes the substance of the organ, that is, it is absorbed. The liver rules over the rightside of the body. According to the Galenic idea the liver is the place of the second digestion and here has the origin of veins and the site of blood formation.

⁸⁸ Fonahn, serial number 2988. The pulmonary vein (actually has not one but 4 pulmonary veins) arrives in the left atrium from the lungs and does not leave the left ventricle toward the lungs. The description of the role of the artery is rather fits pulmonary artery, starting from the right ventricle to the lungs. The two heart valves mentioned later (left venous or mitral valve), on the other hand, are true for pulmonary vein(s) in the left ventricle. 'The veins that come to him, to the finest part of the heart', can be pulmonary veins (*vv. pulmonales*).

⁸⁹ The right and left halves of the heart are defined not only anatomically but also philosophically. The left half of the heart, and within it the left ventricle, contains the finer, more ethereal matter. This is the nobler part of the heart, and the arteries that follow from it, which transmit the divine immortal part of the soul to the rest of the body, are nobler than the veins to the rightside of the heart (by the lower empty vein / *v. cava inferior*), which are denser, heavier, nutrient-filled blood is

penetrate. This artery is single-layered, unlike other arteries, so it is called a venous artery (*aṣ-ṣiryān al-warīdī*). It was created as a single layer to be more refined, more flexible, and more suitable for expansion and contraction. Thus it is better suited to disperse the fine-textured, vaporous blood into the lungs that corresponds to the essence of the lungs and is very similar to the blood that has matured in the heart. This blood does not need further maturation than the blood that enters the heart through the empty vein. Mainly not because the lungs are close to the heart, so hot, mature nutrients can be easily accessed. The part that pulses in it is a thin / small part, but you should not be afraid of it breaking apart during pulsation as it is vital. It does not need to increase its mass like the other strong arteries adjacent.

The arterious vein (*al-warīd aṣ-ṣiryānī*) (*vena arteriosa / pulmonary artery*)⁹⁰ is close to the lungs; in fact, it is only the posterior part that runs past the spine.

The venous artery (*aṣ-ṣiryān al-warīdī*) (*arteria venosa / pulmonary vein*)⁹¹ branches only in the front half of the lung and then penetrates deep into larger and smaller parts. If we compare the strength (*al-witāqa*) and the elasticity (*as-salāsa*) of this 'artery' (*aṣ-ṣiryān al-warīdī*), which allows it to easily expand and contract and thus disperse the blood that is in it, then we find that it needs flexibility more than it does strength and thickness.

The other artery, whichever is greater, was called the aorta of Aristotle. As it exits the heart, it gives two branches: the larger one bypasses the heart; and offers branches in different parts (*a. coronaria sinistra*). The other unit, the smaller one, turns around and branches off in the right ventricle (*a. coronaria dextra*). What is left out of these two small blood vessels; it is the aorta itself. As it separates from the heart, it splits into two parts: the larger part (*arcus aortae / aorta descendens*) nourishes the descending blood vessels (*murašših lil-inḥidār*), as the smaller vessel (*truncus brachiocephalicus*) travels upwards into the blood vessels above the heart (*murašših lil-iṣ'ād*).⁹² The artery (*aortic descendens*) that nourishes downward blood vessels has been created to accommodate the larger number and size of parts that are under the heart. At the aorta exit, there are three complex valves that open from

delivered. The wall of the left ventricle is actually the thickest part of the heart. This is where the great blood stream begins, the blood pumping into the aorta with tremendous force. The aortic valve therefore ossifies into older mammals in old age. (This has already been observed by Ibn Sīnā. 1987: Volume 2, Book 3. 1196 p.) The right ventricle has a much thinner wall than the left.

⁹⁰ Fonahn, serial number 3340.

⁹¹ Only one lung vein is examined or described.

⁹² Blood flows in the blood vessels very slowly, oozes, according to the idea taken from antiquity.

the inside out.⁹³ If there were only one or two valves here, it would not be enough to do its exercise just by increasing its size. It would be difficult to move the two valves. And if there were four valves here, they would have to be very small, unable to do their exercise. If they were to increase in size, the path of blood would narrow. The venous artery (*aš-širyān al-warīdī*) (*v. pulmonalis*) has two valves that turn inward,⁹⁴ and the number of its valves has been reduced to two because it does not require perfect calm. Here, more flexibility is needed to make it easier for fog-like vapors to break out, flow out, and blood to enter the lungs.

Anatomy of the ascending artery

Of the two branches of the aorta, the ascending branch (*truncus brachiocephalicus*) becomes bisected.

1. The larger (*a. carotis communis*) goes upwards towards the gum (*al-litta*)⁹⁵ and then turns diagonally to the right until it reaches the soft flesh of the thymus (*al-laḥm ar-raḥū at-tūṭn*).⁹⁶ Then it will split into three branches here. Two of these are the two arteries called *as-subātān* (*a. carotis*)⁹⁷ and rise to the right side and left side along with the two external jugular veins (*al-widāḡān al-ḡā'irān / v. jugularis externa*). The third branch (*a. subclavia dextra*) runs in the sternum (*al-qaṣṣ / sternum*), in the real ribs (*al-adlā' al-awwal al-ḥullaṣ / costae verae*)⁹⁸, and branches off in the first six cervical vertebrae at the sides of the clavicle (*al-tarqūwa / clavícula*)⁹⁹ to finally reach the tip of the shoulder (*ra's al-katif / acromion*)¹⁰⁰ and then the various parts of the palms.
2. The smaller branch (*a. subclavia sinistra*) moves towards the armpit (*al-ibt / axilla*) (*a. axillaris*) and then divides into components like the third branch of the more giant.¹⁰¹

⁹³ The aorta originates from the left arterial mouth and has 3 semilunar heart valves that originate in the inner perimeter of the mouth and open outward from the heart.

⁹⁴ The pulmonary vein opens into the left venous mouth, enters the left ventricle through two cuspidal valves. The heart valves open inwards towards the ventricle.

⁹⁵ Fonahn, serial number 266. The meaning of "gum" is difficult to interpret here, but the word means only that, in other dictionaries as well.

⁹⁶ Fonahn, serial number 1812. The thymus gland (thymus) is located above the heart, where the large blood vessels enter and exit the heart. The thymus leans against the base (upper part) of the heart, behind the grip of the sternum. In Arabic, "raspberry-like loose flesh."

⁹⁷ Fonahn, 2986, serial numbers 2987. Three arteries branch from the aortic arch: *truncus brachiocephalicus*, *a. carotis communis sinistra* and *a. subclavia sinistra*. The *truncus brachiocephalicus* then splits in two, and these are the *a. carotis communis dextra* and the *a. subclavia dextra*. So the rightside of the two common carotid arteries does not branch directly from the aorta, but starts from the brachiocephalic trunk towards the head.

⁹⁸ Fonahn, serial number 1136.

⁹⁹ Fonahn, serial number 3226.

¹⁰⁰ Fonahn, serial number 3226.

¹⁰¹ From the subclavian artery (*a. subclavia*) to the armpit will be axillary artery (*a. axillaris*), then moving on to the upper arm called

Anatomy of the two carotid arteries (*aš-širyānān as-subātiyān / a. carotis communis sinistra et dextra*)

Both carotid arteries split into two branches reaching the end of the neck:¹⁰² an external (goes in front) (*a. carotis externa*) and an internal (goes at the rear) (*a. carotis interna*).

The branch in front (*a. carotis externa*) splits in two:

1. For an inner branch, [this branch actually belongs to the *a. carotis interna*], which extends to the tongue (*al-lisān*) and the inner half of the jaw muscle (*al-'adl al-fakk al-'asfal / musculus masseter*) (*a. maxillaris interna*).
2. An outer branch which rises upwards to the anterior half of the ears (*quddām al-uḡunayn*) to the temporal muscles (*'adl aš-šudḡayn*) (*a. temporalis superficialis*) and leaves many branches in them while the top of the head (*qullat ar-ra's*). Here, at the top of the head, the blood vessels originating in the right side and the left side respectively come together.

The posterior branch (*a. carotis interna*)¹⁰³ is also divided into two parts:

1. Most of the smaller branches move backward and branches into the muscle surrounding the joint of the head. The rest turns towards the posterior base of the brain (*qā'ida mu'aḥḥar ad-dimāḡ*), inward into the old hole (*taqb 'azīm*)¹⁰⁴ at the lambda seam (*ad-dar al-lāmī*).¹⁰⁵
2. The more giant then enters the hole in front of the spot, which is in the clavicle (*al-'azm al-ḡaḡarī / pars petrosa ossis temporalis*)¹⁰⁶ and continues towards the miracle net (*aš-šabaka / rete mirabile*).¹⁰⁷ From

brachial artery (*a. brachialis*), in the forearm it is divided into radial artery (*a. radialis*) and ulnar artery (*a. ulnaris*) and then finally reaches the palm of the hand.

¹⁰² The common carotid artery branches off at the lingual bone into an outside and an inside branch: external carotid artery (*a. carotis externa*) and internal carotid artery (*a. carotis interna*). This site is at the third cervical vertebra, at the upper edge of the thyrcartilage.

¹⁰³ The internal carotid artery actually travels without branching into the skull, where it is divided into several branches and is involved in the blood supply to the brain.

¹⁰⁴ The two carotises have a separate entrance opening into the skull, not through the 'bighole' (*foramen occipitali magnum*), but through two small openings (right and left) next to the 'bighole.' They enter the temporal bone through the foramen caroticum (through *canalis caroticus*) at the base of the pars petrosa belonging to the temporal bone.

¹⁰⁵ The lambda suture attaches the occipital bone to the two wall bones of the skull. (*sutura lambdoidea*)

¹⁰⁶ Fonahn, serial number 535.

¹⁰⁷ Fonahn, serial number 2956. The term *rete mirabile* was coined by Galen, who discovered the division of the internal right and left carotid arteries in some species of animals, but not in human. Joseph Hyrtl wrote about this: *Dieses Rete mirabile existirt wirklich, aber nicht im Menschen, sondern bei den Katzen, Schweinen, Delphinen, und besonders entwickelt bei den Wiederkäuern, wo es seiner Grösse und seines Reichthums wegen.* (Onomatologia Anatomica. Geschichte und Kritik der anatomischen Spracheder Gegenwart. Wien, 1880: 450 p.) The internal carotid artery lacking in cow's brain (ruminant), but is

here, a network of blood vessels is intertwined with other blood vessels, and layers are deposited on layers, and grooves follow on the tracks; they cannot be separated from each other because they are connected, forming a network.¹⁰⁸ The blood vessels give branches forward, backward, right, left, spreading in the net (*aš-šabaka*) (*rete mirabile*). Then a couple of these gather; as if these two are worth the first. The meninges form a hole for them where they can ascend to the brain. They then branch into the soft meninges of the brain (*al-ġiṣā ar-raqīq* / *pia mater*),¹⁰⁹ then into the brain (*ġirm ad-dimāġ* / *medulla*),¹¹⁰ inside, and into the thin membrane lining the inside (*ṣifāq buṭūnihi*).¹¹¹ It reaches the openings of the small blood vessels that previously ascended here, and then the beginnings of the small downward veins. [They climb, they descend] because this is the best way for the continuous flow of blood to reverse at the ends of the blood vessels. The ascending branch is where the immortal divine soul (*ar-rūḥ*) enters, which is subtle, agile, and has an upward motion, and has no need to turn by the vessel of the carrier or to be emptied. If this were to happen, it would lead to the emptying of the blood that carries it and make it harder for the soul to move because the soul is moving upwards more easily. The movement and subtlety of the soul are enough to manifest in the brain what is needed, and, the brain to heat it. Therefore it is covered with a net under the brain, and therefore the arterial blood returns, and with it

the soul too, and it becomes similar¹¹² to the nature of the brain (*mizāġ*) after maturation. It then gradually becomes accessible in the brain and, in the network between the skull and the hard meninges.

Anatomy of the descending artery (descendant aorta) (aš-širyān an-nāzil) (aorta descendens)

The descending artery (*aorta descendens*) first progresses straight to the fifth vertebra¹¹³ in contrast to the base of the heart (*ra's al-qalb*) where the thymus (*aḫ-tawṭa*) is also present as the support and reinforcement of the heart. It is located between it and the vertebrae of the spine (*'izām aš-ṣulb*) and the esophagus (*al-marī*). As soon as the artery reaches this place, it turns to its right so it does not pass through it. It then ascends to the diaphragm (*al-ḥiġāb*), attaching to the membranes to not constrict the blood vessel.¹¹⁴ After reaching the fifth vertebra, it takes a turn and starts down the spine until it reaches the sacrum (*'azm al-'aġuz*). As it passes through the chest, it leaves hair-thin small branches that disperse in the blood vessels of the lungs (*wi'ā 'al-ri'a*) (*a. bronchialis*).¹¹⁵ Its limbs reach the trachea and give branches at each vertebra along the way until it finally reaches between the ribs and the spinal cord. From the chest, two arteries reach the diaphragm (*al-ḥiġāb*), separating to the right and to the left. One of the arteries (*aorta abdominalis*) branches to the stomach, liver, spleen.¹¹⁶ A branch of the liver becomes free toward the bladder.¹¹⁷ An artery then grows and goes to the mesenterium (*al-ġadāwil*), which is located around the small intestine and colon (*al-am'ā' ad-diqāq wa-l-qulūn*).¹¹⁸ Then three arteries separate from this (the

found in his eyes. The *rete mirabile* is a network of blood vessels in which many branches of the branching artery continue to merge into an artery again. *Rete mirabile* slows down arterial blood flow. It is found in the cranial cavity, in the eye, in the glomeruli of the kidney. Galen believed that the life spirit (*spiritus vitalis*) was transformed into the animal (or animate) spirit (*spiritus animalis*) in *rete mirabile* and was then distributed throughout the entire body from the brain along the nerves.

¹⁰⁸ The artery, along with its bony duct, bend at right angles and reaches the sphenoidal bone almost horizontally. Its course here is peculiar: on eachside of the body of the sphenoidal bone there are sinuses in double membrans in which the venous blood of the brain flows. This vein of these sinuses is called *sinus cavernosus* and, in its cavity in addition to the internal carotid artery, important cerebral nerves also run. These formulas are connected by connective tissue beams that make the interior of the venous sinus cavernous, as described herein.

¹⁰⁹ According to Fonahn's dictionary (serial number 1407.) it is the *arachnoidea*. The *arachnoidea* does not contain blood vessels, while the soft meninges (*pia mater*) are rich in blood vessels. The *arachnoidea* and *pia mater* together form the soft meninges (*leptomeninges*). The soft meninges are the third meninges that lie tightly against the surface of the brain.

¹¹⁰ Fonahn, serial number 1625.

¹¹¹ Among these blood vessels is, for example, the *posterior commonartery*, which establishes a connection to the *internal carotid artery* and between the posterior branch of the *posterior cerebral artery* (*vertebral artery*). The *choroidal artery* leads to the lateral ventricles of the brain and forms a dense loop system in them that produces liquor.

¹¹² As a result of the third digestion, which takes place in the organs and which actually corresponds to the use of the nutrient. The food brought by the blood will be part of the brain, absorbed, and incorporated into the tissues of the brain.

¹¹³ The heart is located between the 2nd and 5th ribs.

¹¹⁴ According to today's division, the descending aorta has a thoracic section (*aorta thoracica*) that extends from the end of the aortic arch to the diaphragm and the other (*aorta abdominalis*) that extends from the diaphragm to the abdomen. The thoracic aorta enters the abdominal cavity through the hiatus aorticus (aortic opening) of the diaphragm in front of the spinal column. This opening (tendonous ring) is between the two tendonous-structured legs (*crus*) of the diaphragm and the spine (at the height of the 12th vertebrae), so it is not affected by the contractions of the diaphragm, the blood supply to the aorta is continuous, i.e. it does not narrow the blood vessel.

¹¹⁵ The visceral branches of the thoracic aorta include the arteries that supply the tissues of the lungs (*a. bronchialis*), the esophagus (*aa. oesophagae*) and the pericardium (*rami pericardiaci*).

¹¹⁶ The odd visceral branches of the abdominal aorta supply the liver (*a. hepatica*), the stomach (*a. gastrica*), the pancreas (*a. pancreatica*), and the spleen (*a. lienalis*).

¹¹⁷ One of the branches of the artery leading to the bladder, the internal iliac artery (*a. iliaca interna*) (*a. vesicalis inferior*) to the lower part of the bladder, or *aa. vesicales superiores*, which runs to the upper part of the bladder, i.e. does not originate from the liver.

¹¹⁸ The odd visceral branches of the abdominal aorta supply blood to the small and large intestines. These are the (*a. mesenterica superior*) upper mesenteric artery supplies the small intestine and (*a. mesenterica inferior*) lower mesenteric artery supplies the colon.

mesentery).¹¹⁹ The smallest of them reaches mainly to the left kidney and branches into its cover layers (*lifāt*) and the surrounding organs (*al-aḡsām*) and gives them life (*yufiduhā al-hayāt*).¹²⁰ The other two blood vessels go to the two kidneys so that the kidneys can extract the aqueous (liquid) part of the blood from them. These two blood vessels most often extract unclean blood from the stomach and intestines, then separate into two arteries and go to the testes / ovaries (*al-untayayn*).¹²¹ Of the two, the artery arriving at the left is always associated in one piece with the artery (*a. renalis*) arriving at the left kidney. The artery that arrives at the left testicle may only come from the left kidney. And the artery that goes to the right testicle always comes from the largest artery (*aš-širyān al-'a'zam / aorta*). It is rarely associated with any blood vessel (*istaṣhaba šay'an*) that reaches the right kidney. Then two smaller arteries separate from this large artery and branch into the blood vessels of the mesentery (*ḡadāwil al-'urūq / via venarum / mesenteric vessels*) that surround the rectum (*al-ma'ī al-mustaḡīm*) (mesorectum). The tributaries (*šū'ab*) branch out into the spinal cord (*al-nuhā'*) and penetrate the cavities of the vertebrae. Some blood vessels travel to the hips, others to the testicles / ovaries. A small pair of these blood vessels — not the ones we will mention in the case of men and women — end at the anterior (*al-qubl*) and mix with the veins. As soon as the largest artery (*aorta abdominalis*) reaches the last vertebra, it splits into two branches, forming a Greek letter of lambda, along with the vein associated with it (*v. cava inferior*).¹²² One branch turns to the right side, the other to the left side, then they pass the sacrum and run towards the thighs (*aa. iliacaе externaе*). Before returning to the thighs, both give branches to the bladder (*aa. vesicales*) and the navel (*a. umbilicalis*). They meet at the navel. This part is well seen in newborns.¹²³ In a fully developed fetus, the ends of these blood vessels dry out, leaving only their bases, from where the two arteries branch into

the muscle in the sacrum. The artery, which extends from here to the bladder (*al-matāna*), branches into it (*aa. vesicales*), its ends reach to the penis (*al-qaḡḡib*) in men (*a. pudenda interna, a. profunda penis*), in women to the uterus come (*a. uterina*). For women, this is a small pair of wires. The arteries leading to the legs first divide into two large branches in the thighs, laterally (*waḡšīyyan*) (*a. profunda femoris*) and medially (*insīyan*) (*a. femoralis*).¹²⁴ The outer branch also bends towards the inner side and leaves branches in the muscle there, then starts down and turns forward (*a. tibialis posterior*) and gives a large branch to the thumb (*al-ibhām*) and middle finger (*as-sabāba*).¹²⁵ The remainder straightens out of the blood vessel and passes through most of the leg (*a. peronea*) under the veins.¹²⁶ The arteries described include those that travel with the veins: for example, the two blood vessels from the liver to the navel in the abdomen of the neonate (*a. v. umbilicalis*), the branches of the venous artery (*a. pulmonalis / v. pulmonalis*), the artery to the fifth (back) vertebra (*aḡ-ḡārib an-nāfiḡ*) (*arcus aortae*) axillary artery (*a. v. axillaris*), the two carotid arteries (*as-subātān / a. carotis dextra et sinistra*) blood vessels in the diaphragm, the blood vessels penetrating the shoulder with the lateral branches (*a. v. subclavia*), the stomach (*a. v. gastrica sinistra*)¹²⁷, the liver (*a. hepatica, vv. hepaticae*), the spleen (*a. v. lienalis*), the blood vessels leading to the intestines (*a. v. mesenterica inferior*), the blood vessels descending from the fine lower abdomen (*a. v. iliaca communis*) and the blood vessels, which branch off at the sacrum (*'azm al-'aḡuz*) (*a. v. iliaca externa* and *a. v. iliaca interna*). The artery (*aorta abdominalis*) rests tightly on the vein (*v. cava inferior*) that is in the muscle passing by the spine, so that the lower rank of the two carries the nobler (*liyakūn aḡassuhumā ḡāmilan lilašrafī*). As for the limbs, the artery travels deep under the vein to be hidden, and the vein gives it protection. The vein forms a kind of protective shield above it. Arteries are associated with veins for two reasons: one is that the veins attach to the membranes in which the arteries are lined and draw water (*tastaqī mimmā baynahumā min al-'a'ḡā'*) from the

¹¹⁹ It does not start from the mesentery, but the abdominal aorta branches off to both kidneys: *a. renalis sinistra et dextra*.

¹²⁰ According to the medieval idea, the artery transports the life force / spirit (*spiritus vitalis*) from the heart to the target organs. The immortal part of the soul, the *pneuma*, gives life to the organs.

¹²¹ The internal spermatic artery (*a. spermatica interna*) and the ovarian artery (*a. ovarica*) branch off from the abdominal aorta.

¹²² The end of the dorsal vertebrae in the lumbar region 4th-5th at the vertebrae, at the height of the sacroiliac joint. The abdominal aorta (*aorta abdominalis*) forks off into two iliac arteries (*a. iliaca communis*).

¹²³ The common iliac artery splits into two iliac arteries, which form an external branch (*a. iliaca externa*) and an internal branch (*a. iliaca interna*) on each side. The internal visceral branches of the hypogastric artery (*a. hypogastrica* or *a. iliaca interna*) supply blood to the organs of the pelvis on the right and left sides, such as the bladder. In intrauterine life, one more branch was derived from the hypogastric artery. In the fetus, the main branch of hypogastric artery is umbilical artery (*a. umbilicalis*), which adheres to both sides of the bladder and then to the inner surface of the anterior abdominal wall, and run up to the umbilical cord, and through it to the navel ring. After birth, this artery is removed or transformed into a connective tissue bundle in the lateral ligament of the bladder. (*ligamentum umbilicale laterale*)

¹²⁴ The external iliac artery hides under the groin tape (*ligamentum inguinale*), and in the thighs like femoral artery (*a. femoralis*) progresses further down to the popliteal space. The largest branch is the *profunda femoral artery*, which originates a few centimeters below the inguinal region and immediately penetrates deep.

¹²⁵ The tibial artery (*a. tibialis*) is continuation of popliteal artery (*a. poplitea*) in the leg along the tibia. Its end is *dorsal pedis artery*, which runs from the center of the line between the ankles to the first metatarsal bone.

¹²⁶ Accompanying veins are veins that run parallel to the arteries and have a triple layer of walls. In the limbs from the middle of the brachial artery downwards, each artery is accompanied by two veins, the branches of which correspond to those of the arteries.

¹²⁷ Or *v. coronaria ventriculi*, which travels along the small curvature of the stomach and opens into the portal vein.

organs between them. The other is to take the water apart.¹²⁸

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¹²⁸ In the muscle next to the spine, the artery travels over the vein, “the lower rank carries the nobler one,” while in the limbs, on the contrary, the vein travels over the artery to protect it as a kind of “protective shield”.