

Texts and Documents

Malpighi's *De Polypo Cordis*: An Annotated Translation

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Introduction

Malpighi's *De polypo cordis* (1666) represents a significant contribution to the understanding of blood, its composition and its clotting. In this work, written during his occupation of the primary Chair of Medicine at Messina (1662–66),¹ he recognized, albeit dimly, fibrinogen as a regular component of blood, and began to investigate the conditions which provoke or prevent clotting, either intravascularly or in shed blood. His microscopes had enabled him to discover the pulmonary capillaries five years earlier. Now he provided the first precise description, aided by microscopy, of the laminar structure of a clot and the sequence of its formation. He specified how the appearance of post-mortem clot in the left and right sides of the heart differed. Here too it can be claimed that the first sighting of red blood cells is recorded, although Malpighi was at the time far from appreciating their significance.

Preceding Work

The term "Polypus cordis" was first used by the audience of leading physicians of Amsterdam, at an autopsy by Nicolaas Tulp.² Then in 1654 Pissinius published the first

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¹ His life is described in detail by Howard B Adelman, *Marcello Malpighi and the evolution of embryology*, 5 vols, Ithaca, NY, Cornell University Press, and London, Oxford University Press, 1966, vol. 1, *The life and works of Marcello Malpighi*. It is of interest that after his death, no polyps were found in his own heart, according to the report by Lancisi;

he died from cerebral haemorrhage; see *Phil. Trans. Roy. Soc.*, 1697, 19, no. 226: 467–71.

² Nicolaas Tulp (1593–1674) was Praelector in Anatomy at Amsterdam, 1628–1652. Rembrandt's famous painting of Tulp's anatomy lesson was commissioned in 1632. Tulp's *Observationes medicae*, Amsterdam, Daniel Elzevir, 1641, p. 51, contain as item 27 of Book I the description of Polypus Cordis. It was found at autopsy on the victim of a stroke. Much phlegm (pituita) had been found in the cadaver's cerebral veins, regarded as the seat of the stroke, and search for its origin began in the nose, where nasal polyps were customarily regarded as derived from phlegm, but without success there. The search moved to the heart and revealed the cardiac polyp. Previously, Tulp noted, Caspar Bauhin (*Theatrum anatomicum*, Frankfurt-am-Main, Theodor de Bry, 1621, 2nd ed., appendix, figures 1 and 2 in Tabula 9) had found something similar, but consisting of fatty material rather than of phlegm.

treatise on cardiac polyp.³ Although his *Epistola de cordis polypo* is only eleven pages long, it identified key issues with striking clarity. Polyps in the heart seem frightening, but are not a new entity, although the name is new; he did not know who had first used it. He traced its origin to the resemblance to nasal polyp and aquatic polyps. He described two cases of his own, and discussed his answers to six crucial questions. Is diagnosis during life possible? How quickly do polyps develop? Is pre-existent fever a necessary condition? Can cardiac polyp cause death on its own? How long could its presence be compatible with life? And what can be done to deal with it? He held that cardiac polyps developed during life, though they might in some cases prove fatal almost at once. He concluded by mentioning that Tulp's recently ("nuperrime") printed *Observationes* had just reached him as he finished his own treatise.

Malpighi's is the second treatise about cardiac polyp. After the treatise's appearance, he devoted little further attention to the topic himself.⁴ Very substantial attention was however paid to cardiac polyps by later authorities.⁵ Twentieth century understanding of their history and heterogeneous nature is described by Mahaim, whose book explains how "cardiac polyp" cannot be identified with any single pathological entity of to-day. Some polyps were in fact blood clots formed post-mortem, and thus not indicative of disease. Some were clots formed before death in consequence of mitral stenosis. Some were due to more recondite disorders, such as actual tumours in the heart.⁶

Previous Translations

There are translations into French (1683)⁷ and German (1939)⁸ but my own previous translation, the only translation into English, is not annotated, and not generally

³ This is Sebastianus Pissinius of Lucca. From the Elogium at the opening of his *De diabete dissertatio* (included under a common title page with his *Epistola de cordis polypo*, Milan, The Archiepiscopal printer, 1654) which states that he was then in his seventy-third year, it can be deduced that he was born about 1581. He had previously published *De cordis palpitatione cognoscenda et curanda*, Frankfurt, Marnius, *et al.*, 1609, and through the help of John Symons, Curator of Early Printed Books at the Library of the Wellcome Institute for the History of Medicine, two other works of his are known to me: *De cyanei lapidis viribus*, Lucca, 1617, and (under the Italian form of his name Pezzini) *Del modo di purgare le case e robbe infette*, Lucca, 1631.

⁴ Within his *Opera posthuma* (London, A & J Churchill, 1697) are two pages (44–5) which mention that among those predisposed to cardiac polyps are melancholics, those with "lues gallica" (syphilis), and others in whom "coagulative acid salts are plentiful"; Malpighi is at pains to assert that cardiac polyps could form during life, and relied chiefly on the presence of symptoms such as in his view would result from the presence of cardiac polyps. In this insistence he arrayed himself in opposition to authors such as Theodor Kerckring

(*Spicilegium anatomicum*, Amsterdam, Frisius, 1670, case 73, p. 145) who maintained that all cardiac polyps had formed after death. Malpighi's *Correspondence* (ed. Howard B Adelman, 5 vols, Ithaca and London, Cornell University Press, 1975, vol. 2, letter 382 of 20 March 1679, and vol. 3, letter 433 of 26 January 1684) makes brief reference to the finding of polyps at two autopsies. Malpighi did not seem prone to diagnose cardiac polyp during life; in the 63 *Medical consultations* of his (ed. novissima, Venice, Corona, 1747), 5 relate to cases of palpitation or similar symptoms; in only one (consultation 30) did he regard cardiac polyp as the likely cause, and in one other he explicitly excluded it.

⁵ Approximately six per cent of nearly 6,000 autopsy accounts collected in Theophile Bonet's *Sepulchretum* (Geneva, Chouet, 1676) refer to the presence of cardiac polyp. Morgagni and Haller both discussed the topic.

⁶ Ivan Mahaim, *Les Tumeurs et les polypes du coeur*, Paris, Masson, and Lausanne, Roth, 1945.

⁷ M. (Monsieur) Sauvaille, *Discours anatomiques sur la structure des viscères . . .* par Marcel Malpighi, Paris, d'Houry, 1683 (hereafter Sauvaille).

⁸ 'Marcello Malpighi *De polypo cordis dissertatio*', Uebersetzung und Anmerkungen von Käthe Heinemann; annexed to Ludwig Aschoff, *War*

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available.⁹ After nearly forty years, I found it inaccurate at numerous points. All these translations have been compared during the preparation of the present revised translation.

Text

The editions of Malpighi's works were listed by Frati.¹⁰ For the present purpose the first edition,¹¹ the 1669 edition,¹² the London *Opera omnia* of 1686–7,¹³ and the Leyden *Opera omnia* of 1687 were examined.¹⁴ The differences between editions are of practical significance only very rarely, and then have been mentioned in the notes.

Translation

De Polypo Cordis Dissertatio

Remarkable morbid states commonly arise in living creatures, through the caprices of Nature or the vagaries of disease. These states I have always considered as shedding much light on the investigation of Nature's true normal method of operation;¹⁵ they indicate the constraints and tendencies of the material which stands revealed in the construction of the animal body. And so monsters, and other mistakes, dissipate our ignorance more easily and reliably than the remarkable perfected mechanisms¹⁶ of Nature. Thus, from the study of insects,¹⁷ fishes, and the first simple stages in the development of animals,¹⁸ the present age has learnt many a lesson denied to its predecessors, preoccupied exclusively as they were with the perfected animal.

Among the manifestations of disease commonly met with in cadavers, Polyp is not the least noteworthy. For it is found in the most deadly diseases, occupying the body's citadel,¹⁹ and research into it can illuminate problems previously baffling. I know that the

die Syphilis von Alters her eine europäische Krankheit?, Freiburger Forschungen zur Medizingeschichte, Heft 2, Freiburg-im-Breisgau, Speyer Verlag, 1939 (hereafter Heinemann).

⁹ *Marcello Malpighi De polypo cordis dissertatio*, transl. J M Forrester, Uppsala, Almqvist & Wiksells, 1956.

¹⁰ Carlo Frati, *Bibliografia Malpighiana*, Milan, 1897, reprinted by Dawsons in London, 1962.

¹¹ *De viscerum structura . . . accedit dissertatio . . . de polypo cordis*, Bologna, Jacob Montius, 1666.

¹² The same two works, London, Jo. Martyn.

¹³ Published from (so far as *De polypo cordis* is concerned) identical type by three different publishers; for details see Frati, op. cit., note 10 above. Referred to hereafter as "London *Op. omnia*".

¹⁴ Leyden, Peter Vander, 1687; referred to hereafter as "Leyden *Op. omnia*". This was the last edition published during Malpighi's lifetime.

¹⁵ "genuina operandi norma, et methodo".

¹⁶ "machinae"; Sauvaille: "chefs d'oeuvre".

¹⁷ Malpighi's work on the silkworm (*De bombice*) was published in 1669.

¹⁸ Malpighi's work on the formation of the chick in the egg first appeared in 1673.

¹⁹ Latin: regia = a palace or fortress; i.e. the heart; Sauvaille: "principale partie de l'homme". Harvey's discovery could be regarded later by Malpighi as degrading the heart: "cor iuxta veteres microcosmi fuisse solem, Regem in corpore, nunc Asinum molarem esse . . ."; (Malpighi, op. cit., note 4 above, p. 87) it used to be the sun of the microcosm, the ruler of the body, and now is only the donkey that turns the millstone.

painstaking hard work of the distinguished investigators Bartheoletti,²⁰ Tulp,²¹ Bartholin²² and others²³ has revealed how Polyps develop in the heart, and much too has been unearthed about their causes, especially by the celebrated Piscinus.²⁴ Indeed, my attempt may turn out to be in vain; but I may perhaps add this small contribution, to smooth the path for scientific research.

The name “Polyp” was drawn from the resemblance to the aquatic creature,²⁵ and became applied to a particular type of nasal tumour.²⁶ Later, a swelling mass was observed in the heart,²⁷ and thus a new disease of the heart and vessels began to attract attention; though it had been noticed at dissections in previous ages,²⁸ yet it had been overlooked

²⁰ Fabrizio Bartoletti or Bartheoletti (died 1630) held successively the chairs of surgery and anatomy at Bologna, of anatomy at Pisa, of medicine at Bologna, and of medicine and anatomy at Mantua. His book (*Methodus in dyspnoeam, seu de respirationibus libri IV*, Bologna, heredes Dozzae, 1633) has a preface which mentions that the material was contained in lectures given in 1628 (“Anno MDCXXVIII publicis lectionibus explicatum”), so that his use of the phrase polyp in the heart (to be precise, he wrote on what was called “à nobis” “polypodes humor” in the heart) may be regarded as the first, and his own words imply priority without actually claiming it.

In his book (vol. 4 pt 3, ch. 11, p. 329) he wrote that, just as nasal polyp, formed from compacted sluggish and viscid humours, blocks the nose, hangs out of the nasal cavity, and is adherent to it by many roots, so cardiac polyp “infarcit cordis ventriculos, eorundem auricularas opplet, et potissimum cordis vasa obturat.” When he found the auricles, especially the very large right one, filled with a cast of this “mucus” [sic], the distinguished men present at first took it for a fatty body. When he showed it to one Cavallo (who was first a doctor, and later a very respectable “religious”), Cavallo at first thought it so solid that it must be cardiac fibres torn away, but later was entirely satisfied that it consisted of compacted raw humour. It is often seen to block the orifices of cardiac vessels, and extends along these vessels, and also into the pulmonary artery. The material is not blood, but a raw humour solidified, and is supplied to the heart by the liver; through the heart’s (or possibly the liver’s; the Latin is ambiguous) weakness it may accumulate in the heart, and lose its thinner parts because of the heart’s heat, thus becoming solid (cf. “boiling dry”). Hence it propagates from heart to vessels, not *vice versa*. How it gets from right to left ventricle is hard to grasp, but it does (“et tamen re vera transmittitur”).

²¹ See note 2 above.

²² Thomas Bartholin the elder, (1616–80; professor of mathematics at Copenhagen from 1647, and then of medicine from 1648) *Anatomia*, 3rd ed., The Hague, Vlacq, 1655, p. 263, listed a number of anomalous items found within the heart by his predecessors, but he did not here use the name polyp, and cannot be said to have made any painstaking study. Apart from his publication of Michael Kirsten’s case (note 31 below) I cannot find any mention of cardiac

polyp in the works of the Bartholin family, despite Malpighi’s fulsome words.

²³ Apart from Pissinius, about to be mentioned, I can find no other published predecessor of Malpighi who used the term polyp in relation to heart contents.

²⁴ This is Sebastianus Pissinius of Lucca; see note 3 above.

²⁵ “piscis”; but a polyp is not a fish in to-day’s nomenclature.

²⁶ The nasal polyp is described and its treatment discussed in the Hippocratic work *Affections*, section 5; see the Loeb Hippocrates, vol. 5, transl. Paul Potter, Cambridge, Mass., Harvard University Press, 1988; also by Galen in *Περὶ Συνθέσεως Φαρμάκων τῶν κατὰ Τόπους*, bk 3, ch. 3, (*Claudii Galeni opera omnia*, 20 vols, ed. C G Kühn, Leipzig, C Cnobloch, 1821 (hereafter Kühn), vol. 12, p. 681) and elsewhere.

²⁷ “praecordia”: properly this word means diaphragm, but from the context of this treatise it is clear that Malpighi used it as a synonym for heart, although Heinemann gives “Brusthöhle” (thoracic cavity), and Bruno (J P Bruno (reviser), *Castellus renovatus: lexicon medicum*, Nuremberg, Tauber, 1682) gives “diaphragm”, citing Galen. John Harris, *Lexicon technicum*, 5th ed., London, Walthoe, et al., 1736, gives for praecordia “all the Intrails in the Chest or Thorax”.

²⁸ Comparable observations had been made for instance by Antonio Benivieni (*De abditis nonnullis ac mirandis morborum et sanationum causis*, transl. Charles Singer, Springfield, Illinois, C C Thomas, 1954; original publication in 1507), who mentioned “a small piece of dark flesh shaped like a medlar in the left ventricle of the heart” (p. 85, case 35) and “in the left ventricle of the heart a hardened callus as big as a nut” (p. 161, case 81), yet seemed to attach no great importance to these findings; Vesalius, however, (Andreas Vesalius, *De humani corporis fabrica*, in his *opera omnia*, 2 vols, Leyden, Nivié and Verbeek, 1725 (original publication 1543) vol. 1, lib. 1, ch. 5, p. 17), was impressed by a two pound mass of glandular yet blackish flesh which he found within a heart, distending it like a uterus, and apparently accompanied in life by intermittent loss of pulse beats and finally by gangrene of the left leg. Morgagni (*De sedibus et causis morborum*, 2nd ed., Padua, Remondiniani, 1765, *Epistola Anatomica-medica* 24, art. 22) gave a catalogue of similar observations.

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and ignored. Printed illustrations²⁹ of Polyps are available by Tulp³⁰ and Bartholin.³¹ A Polyp may practically fill the ventricles of the heart³² and the lumina of neighbouring vessels with extended multiple long feet; but the location it adopts is not invariable, nor the shape well-defined. At times, shaped like a small placenta,³³ it may occupy the lumen of the ventricles, and have long branching extensions along veins and arteries in all directions, leaving space for the blood to flow; while another, such as I have seen in the cadaver of a most scrupulous young gentleman, is so adherent round the heart's columns and fleshy limbs,³⁴ and so soundly rooted, as to give the impression of an additional ventricle inside the cardiac cavity. It is so solid and unbroken that, on being compressed by the heart immediately around, it ejects the blood that has entered it from the auricle.³⁵ Thus the Polyp's extensions along the vessels are so perforated as to allow blood to pass within them, attached though they are to the vessel walls. The same phenomenon is often seen in the auricles too.³⁶

The right ventricle³⁷ generally contains a larger mass of this Polyp than the left, as I have frequently found. And Bartheoletti reports the same thing of the right auricle,³⁸ which Riolan confirms.³⁹ The colour too is commonly found to differ; the Polyp occurring in the right side of the heart tends to be grey, resembling that of bacon fat,⁴⁰ or the secreted juice⁴¹ usually called phlegm, and sometimes exhibits red or blackish spots. On the other hand, in the left side the colour is usually dark, and the Polyp more compact.

This abnormal outgrowth exhibits a structure of its own. It shows a widespread mass of membranes, one on top of another, which in their nature are reminiscent of nervous

²⁹ The texts all give "polyporum figuram et icones graphice descripti occurrunt a Tulpio et Bartholino", but both Sauvalle ("les planches que Tulp . . . nous ont données representent . . .") and Heinemann silently translate as if they read "figurae" (nominative plural), and I have done the same.

³⁰ For Tulp's account see note 2 above; the accompanying "Tabula" depicts a substantial mass lying within the right side of the heart, although Tulp's written account and the index lines in the figure specify the left side. This error was repeated later in the case of Dr May's Monster (Edward May, *A most certaine and true relation of a strange monster or serpent found in the left ventricle of the heart of John Pennant, Gentleman, of the age of 21 years*, London, George Miller, 1639), where it was detected by Richard A Hunter and Ida Macalpine, 'Dr May's monster: a chapter in the history of the circulation of the blood', *St Bartholomew's Hospital Journal*, 1957, 61: 184–93.

³¹ Thomas Bartholin, Professor at Copenhagen, *Historiarum anatomicarum rariorum centuria [sic] III et IV*, Hafniae, Haubold, 1657. Centuria III, historia 17, p. 39, describes an autopsy at Hamburg by Michael Kirsten on a child, which revealed extensive masses within the right side of the heart and extending outside it, together with similar items in the root of the aorta, and there is a Figure of these, but no discussion of their development, and not even a clinical history.

³² It is not necessarily implied that one and the same polyp could occupy both ventricles.

³³ "placentulae instar"; Bruno (op. cit., note 27 above) states that placentula means a miniature placenta, in the obstetric sense.

³⁴ "lacertos"; the normal heart has no limb-like protuberances with free ends, and such would be mechanically ineffectual, but perhaps Malpighi studied material in which one end of some papillary muscles had been freed by disease or decomposition.

³⁵ This is probably a finding during autopsy, rather than a speculation on what might go on *in vivo*.

³⁶ I.e. to-day's atria, and so throughout the present translation.

³⁷ Reading "ventriculo" with the 1669 edition for "ventriculi" of London and Leyden *Op. omnia*.

³⁸ But only in his own one case!—op. cit., note 20 above, p. 329.

³⁹ Johannes Riolan *filius* (1580–1657; professor of anatomy and botany at Paris, also physician to Henry IV, Louis XIII and Maria de Medici), *Encheiridium anatomicum et pathologicum*, Leyden, Wyngaerden, 1649, Lib. 2, cap. 8, p. 226. Riolan wrote that fleshy or fatty pieces sometimes get stuck in the right auricle.

⁴⁰ Reading "laridi" with the other editions consulted, not the "luridi" of the Leyden *Op. omnia*.

⁴¹ Latin "succus" is thus translated throughout.

tissue,⁴² but with a certain sliminess. Scratching breaks it up visibly into long tough threads, and its extensions show this especially clearly, falling apart like a bundle into threads like nerve fibres.

It is, I see, still not known from what material a Polyp originates. The view that it is a piece of fat has found favour with many; others have regarded it as phlegm, solidified within the heart. Yet the particular nature⁴³ of the phlegmatic humour is, I find, up to now unknown to the Schools; the disorders assigned to the influence of this one of the four humours accord poorly with the juice which we call phlegm when we perceive it.⁴⁴ The phlegm may be supposed to be a faculty residing in the mass of blood, like a nourishing humour, but resembling the faculty of an ideal entity, imperceptible to sense, whose properties are generally known.⁴⁵ Equal difficulty besets those who deny⁴⁶ that a Polyp is part of the blood, but regard it as a raw humour, supplied to the heart by the liver, which becomes solid and loses its thinner parts as the heart's heat wanes.

Since I was unable entirely to concur with these or similar views, I felt that the material of a Polyp deserved careful research. Many a possible material occurred to me—including the substance of blood serum solidified by fire. However, as I have often found, the material of a Polyp does not, when heated, all settle into a stable substance retaining the same mass; it throws up bubbles (filled first with serum and later with vapour),⁴⁷ diminishes greatly, and on thorough boiling grows quite thin, which is not the case with serum capable of congealing. So I considered that other sources drawn from blood should be sought. And in the end, the congealed membranous crust on the surface of drawn and cooled blood finally came to mind; enquiry into it will reveal the source material⁴⁸ and manner of formation of a Polyp, since the appearance arises similarly in both cases.

⁴² Nervous and fibrous tissue tended to be equated ever since classical times; presently the sight of a fibrous mesh under his microscope makes Malpighi refer to "nerve-like threads", and Bruno (op. cit., note 27 above) mentions under "nervinus, nerveus, nervosus" that these words refer to the Parts that are of the nature of nerves, or those approaching that nature and its appearance, such as fibres, ligaments, coats etc., which are everywhere called "Partes nervosae".

⁴³ The Latin is "existentiam et proprietatem"; but the long past history of the humour phlegm makes it absurd to translate: "The existence of the phlegmatic humour is up to now unknown in the Schools." Further, the word "existentia" is unknown to classical and post-classical Latin, and absent from Du Cange's *Glossarium mediae et infimae latinitatis*; the *Thesaurus linguae latinae* mentions theological and philosophical contexts for "existentia", including "res" and "materia" as synonyms, which suggest the translation "particular nature" used here for the word. Sauvaille gives "vertu", Heinemann "vorkommen".

⁴⁴ According for instance to Jean Fernel (*De externis corporis affectibus* within his *Universa medicina*, ed. postrema, Geneva, Stoer, 1637, lib. 7, cap. 3) they were tumours, tubercles and pustules "ex

pituita", maybe thin, watery and mucous, or thick and even glassy or "gypsea"; oedema, ascites, hydrocele; "scirrhus", ganglia, hard glandular swellings which might release soft material; nasal polypi; venous varices. Some of these are obviously soft and slimy, but others hard indeed!

⁴⁵ "depraedicantur", the London *Op. omnia* reading; the Leyden *Op. omnia* has "depraedicatur". Alex. Souter (*Glossary of late Latin to 600 A.D.*, Oxford, Clarendon Press, 1949) gives "proclaim" as the meaning. Sauvaille gives "font grand bruit", but for some reason Heinemann translated: "Eigenschaften werden nicht [sic] genannt". The whole sentence is syntactically obscure; it runs: (pituita) "et licet ut alimentalis humor in massa sanguinis potentia contineri credatur, velut idealis tamen entis sensum effugientis; proprietates depraedicantur."

⁴⁶ Like Bartholetti (note 20 above).

⁴⁷ "flatus".

⁴⁸ "minera", a word imported from French into scientific Latin, and according to Bruno (op. cit., note 27 above) meaning an earthy source for minerals and metals, also "caussa vel materia morbifica". Sauvaille: "matière"; Heinemann: "geheimnisvolle Bau".

I know diverse theories have been propounded about this crust on blood; many have regarded it as part of the chyle, or later as a nervous juice;⁴⁹ some have taken it for the purer portion of blood, which on thorough boiling of blood,⁵⁰ though previously red and soft, becomes white and tenacious. I cannot presume to assail the position of such authorities, but will set forth my own ideas, slight though they are, as convincingly as possible.

The distinguished gentlemen who regard chyle, or else a nervous juice, as the origin of a Polyp are, I think, particularly influenced by the similarity in substance and colour in each case; besides, the materials proposed can find entry into the veins, which contain the blood. If I may follow this approach myself: there is in the blood a more plentiful and more closely similar material for the formation of this crust. I mean the whole mass of clotted blood, called either the red part of blood, or "melancholia".⁵¹ The purple hue of this may mislead our purblind eyes.⁵² However, repeated washings with ordinary water dislodge the incorporated red particles; and then the whole blood clot, which was so red or dark-coloured, in time will grow pale; while the water, carrying away with it the particles of colour, grows red. If you enjoy a pretty sight, examine this blood with a microscope. You will see a fibrous texture, and a network of nerve-like threads, where small meshes and honeycomb-like⁵³ interstices develop in which lie little pools of reddish ichor. When this ichor is washed out with water,⁵⁴ it leaves the network looking grey, with the naked-eye appearance of a mucous membrane.

A careful examination of the crust of blood will convince you that the network part of the blood is of the same material and nature as the surface crust. Take some clotted blood, having on its surface a plentiful firm white crust, not swollen with coagulable serum, and membranous, soft, and pliable. Split it lengthwise, and wash it repeatedly. Then, as you go on, you will see on its upper part a woven crust of greyish membrane with interstices through it and what are practically vesicles, filled with a transparent and less substantial juice. If you follow this substance as it extends, you will soon find that where the clotted mass of blood begins to turn red, it is split up into fibres and fringes running⁵⁵ downwards, and you will again see small channels and spaces being formed by their neat meshwork, which are swollen and coloured by the red atoms they contain; there are larger spaces too, containing yellowish serum, either alone or mixed with red ichor.

So I think the evidence of our senses is that this white network of the blood contributes the strength of the whole blood clot, giving it a firmer structure; and the difference in appearance,⁵⁶ which has so gravely misled us, is attributable to the difference in colour of

⁴⁹ Jean Pecquet (*Experimenta nova anatomica*, Paris, Officina Cramosiana, 1654, ch. 2) had recently actually seen chyle in the vena cava of a dog, and traced it back to the lymphatic vessels, so that it was entirely credible as a visible component of blood. And Walter Charleton (*Oeconomia animalis*, London, Daniel and Redman, 1659, Exercitatio 9, p. 218) following Glisson, believed that nerves contribute a clear liquid to the contents of lymph vessels, which travels thence to the blood.

⁵⁰ "superassatur"; Sauvaille: "pendant que le sang fermente, et qu'il est poussé par trop de chaleur", but this elaborate periphrasis is not in the Latin.

⁵¹ A blood clot contracts so as to extrude transparent serum, which was thus regarded as the

other part of blood when the dark red clotted part—the "black bile" of traditional humoral physiology—was removed.

⁵² I.e. the clot is not *inherently* red; the real red part can be washed out of it, as what in fact are red cells.

⁵³ "exiguus . . . spatiis et sinibus, velut cellulis": these are not the cells of modern biology, which were not identified until the nineteenth century.

⁵⁴ Reading "qui aqua" with the 1669 edition, not the "qui qua" of the London *Op. omnia* nor the "cui qua" of the Leyden *Op. omnia*.

⁵⁵ "elongari" with the 1669 edition, not "elongati" of London and Leyden *Op. omnia*.

⁵⁶ "discrimen"; Sauvaille's translation is similar, but Heinemann interprets it as "Unheil".

the ichor pent within the tiny spaces. On the upper surface, the white scaffolding of the blood is a close network, with fine meshes; so the top crust that forms is a grey and very compact skin. But as the interstices enlarge gradually, they accept some of the lighter, yellowish serum, or something similar; thus a looser and more yielding structure follows on. In the end, the channels grow more open, and are packed with red matter; then what remains⁵⁷ of the crust gives way at that point to the blood's fibrous network extending downwards. Towards the bottom, the network contains the red atoms compressed by the overlying mass, and so shows a change of substance and colour; it becomes limp, through containing the final fringes of the fibres, and dark, from the crowding of the particles contained in it. Their resemblance to black bile⁵⁸ frequently misleads, but a change in their position restores the purple colour.

The lesson to be drawn here is, I thought, simply that sometimes, in certain diseases, there is a thickening of the coagulable serum held in the interstices of the crust, and also in the whole fibrous part of the blood; hence a pale ashen colour appears, and the sliminess and type of substance we see in clotted serum and in egg white. Not uncommonly, long extensions develop through the whole of the blood, and smaller icicles⁵⁹ attached to them run like a network in all directions, as can sometimes be seen without a microscope. On washing blood in this state repeatedly with water, and shaking out the half-clotted serum which produces⁶⁰ the striking network, small channels become visible hollowed out by the white fibrous part of the blood. Even on prolonged washing, this does not occur with the fine fibrous web on the surface, since new meshes and a more marked whiteness keep appearing.

We may demonstrate the truth of what I say, and approach the facts more closely, in this way; take a Polyp which has solidified in the left ventricle or auricle, and has spots mostly red, or is predominantly darkish. Wash it with plenty of water; and, as small spaces appear in it, it will reproduce perfectly the appearance of blood.⁶¹ Sometimes the major part of a small cardiac Polyp resembles the white crust of blood, but the rest is offshoots which are deep red. Sometimes too, the exterior of a Polyp is white, like a spread of membrane, but the rest is so red as to seem a part of the blood which has clotted within the surrounding ventricle, or vessels, as if in a cup. So one might even suspect sometimes that a Polyp originates from a portion of the whole mass of blood, but the ceaseless assault of the passing blood, like water pouring on it, carries away the red particles, leaving the resistant white fibres behind. To elucidate the question, further tests may be applied to both alike.⁶² If the fibres of blood are diluted with water, or received in warm water as blood emerges from the vein, they grow thinner as they are boiled. And if they are thoroughly boiled, they

⁵⁷ "larva"; Sauvaille: "masque".

⁵⁸ "melancholiae". Haemoglobin at the bottom of a clot becomes deoxygenated, being far from the air, and turns blue. Inversion of the clot restores the oxygenation and the red colour. Malpighi's pupil Carlo Fracassati not only had recently noted this colour change, but offered a penetrating explanation, as reported in *Phil. Trans. Roy. Soc.*, 1667, no. 27, 492. "But Signior *Fracassati* maintains, that this blackish colour comes from hence, that the blood, which is underneath, is not exposed to the Air, and not from a mixture of Melancholy: to prove which he assures, that upon its being expos'd to the Air it changes colour, and becomes of a florid red."

⁵⁹ Latin "stiriae" in all editions. Heinemann (Käthe Heinemann, 'Zur Geschichte der Entdeckung der roten Blutkörperchen', *Janus*, 1939, 43: 1-41, p. 5) notes that in Malpighi's *De omento, pinguedine et adiposis ductibus* (1665) the word "stiria" in the first edition is replaced *passim* in the later editions by "striae" (stripes), but there seems no reason to suggest amendment here.

⁶⁰ "efformante"; "efformo" is a medieval word interpreted by Du Cange (op. cit., note 43 above) as "effingere, exprimere" and by Souter as "shape".

⁶¹ Evidently, as Heinemann notes, of *clotted* blood.

⁶² Presumably to polyp and also to shed blood.

turn into a thin membrane; which is precisely⁶³ what occurs with a Polyp. Further, pouring oil of sulphur⁶⁴ onto any of these products produces a rusty colour.⁶⁵

Polyps generally congeal, and also reach a greater size, more readily in the right ventricle of the heart than in the left, and in the veins of the lungs and head, where they occur not uncommonly, perhaps because the returning mass of blood is already depleted of vaporous and thin particles, especially the red sulphurous⁶⁶ particles,⁶⁷ because of the continual nourishment and transpiration of the organs. When the blood has just been mixed with chyle, and other matter previously alien to it, its white filamentous particles are precipitated by contact with the foreign matter; they next encounter and become entangled in the extensive recesses of the right ventricle or auricle, which are rough and fissured. Thence they can propagate themselves by incorporating similar matter which is flowing past, as happens when stones form in the pelvis, or deposits in water channels; tartaric particles⁶⁸ are retained out of the passing water, which otherwise is clear, because of the roughness of the pipes, or the interaction of contact between similar surfaces. These particles retain other similar ones as they pass by, and so a new tube grows out to line the old.⁶⁹ Hence it is understandable that when Polyps start, they can permeate the lungs and even the head. They are like a new vessel within the old, hollow because the motion of the blood maintains an open channel. This is what happens in aqueducts; and I have seen it occasionally in the bile duct,⁷⁰ where a tartaric crust is deposited on the cellular⁷¹ internal surface, breaks down into a small tube, and gives passage to the bile going through.

So it is likely that Polyps are laid down in the same way as the Bezoar⁷² and similar stones, so that growth takes place with time by the addition of numerous layers. Polyps visibly consist of manifold membranes spread out, with ichor and another part of the blood sometimes separating them; then the fibres touching each other, and the impact and

⁶³ "ad amussim"; Heinemann's "regelrecht" is not accurate.

⁶⁴ Sulphuric acid, probably made by heating sulphur.

⁶⁵ Hydrolysis of ferric sulphate derived from the haem of blood produces brown basic salts.

⁶⁶ Not to be identified with to-day's sulphur; see for example Thomas Willis, *Of fermentation or of the intestine motion of particles in every body*, London, T Dring etc., 1684, p. 1 *et seq.*, where "chymistry" resolves everything into Spirit, Sulphur, Salt, Water and Earth; Sulphur is a little thicker than Spirit, and follows Spirits when they "break forth". Heat, consistency and contexture depend chiefly on Sulphur, as do most colours and odours, fairness and deformity, taste. Sulphur gently moving makes digestion and maturation and sweetness; more movement makes "heat, excess and stink, and even dissolution and flame and Burning."

⁶⁷ The relation of these to the "red atoms" mentioned later in this treatise is uncertain.

⁶⁸ Heinemann finds "tartaric" unsuitable in the context, because of its restriction to deposits from wine (especially acid potassium tartrate), which are not the calcium and magnesium carbonate deposited from hard waters. But Paracelsus had made tartar

something much more all-embracing, the "mother of all diseases" (J R Partington, *History of chemistry*, London, Macmillan, 1961, vol. 2, p. 176); the restriction seems one of modern chemistry.

⁶⁹ In his *Opera posthuma* (note 4 above, p. 44) Malpighi again uses this phenomenon, to defeat the argument that polyp could never be deposited from moving blood, and he points out that deposits from water are not restricted to the lower surface of the inside of the pipe, but occur all round.

⁷⁰ "in biliario ipso poro"; the bile duct, although Heinemann translates: "Offnung der Gallenblase".

⁷¹ I.e. like the cut surface of a honeycomb; the cells (note 53 above) are not the cells of later biology. The honeycomb pattern is well known in the gall bladder but not in the bile duct. However, unpublished notes of Malpighi dated 1666 (Adelmann, op. cit., note 1 above, vol. 1, p. 317) record that he saw a human bile duct "cellulated" like tripe, and his treatise *De hepate* (1669), chs. 5 and 7, shows that he used the nomenclature with perfect precision.

⁷² "A concretion found in the stomachs or intestines of certain wild goats, supposed to be an antidote to poison." (Partington, op. cit., note 68 above, p. 98).

pressure of the bloodstream, bring the membranes together, and compress them into a solid body. In confirmation, I may cite the extraordinary structure and size of a Polyp found at Florence, in a man who died in poverty at the age of sixty-three; the learned Giovanni Alfonso Borelli⁷³ kindly informed me of it. The aorta near the heart had expanded into a tumour the size of two fists, and in it was a Polyp of similar size, without extensions or tails, which consisted of membranous layers set one upon another without interconnection, each no thicker than an ordinary leaf of vellum.⁷⁴ On top of these ran white filaments, resembling the fibres or veins of leaves, and all arising from a greyish trunk. The colour of the layers composing the Polyp was ashen, with some reddish patches, so that the whole structure resembled a cabbage head.

This account makes plain how a Polyp is produced by the deposition of layers, which stay separate, like leaves, if the bloodstream keeps the gaps between them open; but if the blood opens a single channel in the middle and flows right through, or else impinges forcefully on its outside, the Polyp sets like a stone. I am aware that some authorities consider that blood vessels sometimes run through the layers of a Polyp, which I do not so far consider impossible, although I have never seen it. For the blood particles making their way in, when compressed on all sides by the congealing of the fibres, can form tubes, as occurs in a colliquamentum,⁷⁵ and other fleshy outgrowths. The aorta has a conspicuous vein, but on its exterior,⁷⁶ which penetrates its coats with tiny branches, and is particularly obvious in the ox, near the heart.

One is reluctant to say that a plant sometimes grows and flourishes inside us,⁷⁷ though this happens to certain animals, and there is in the blood no lack of slumbering seeds of several things. So the best conclusion from the above observation is this, that these white fibres stemming from a common trunk are the initial skeleton of the Polyp; for the tails of the Polyps I have been able to observe resemble when split a bundle of nerve⁷⁸ fibres. Since the fibrous particles in the passing blood are capable of cohering together, separation of the white fibres generates layers just like leaves, which take a shape and arrangement determined by the passing blood, and by the surrounding aortic wall.⁷⁹ All

⁷³ Borelli (1608–79) was a close associate and mentor of Malpighi from 1656 at Pisa onwards. His posthumous *De motu animalium* (ed. novissima, Leyden, Peter Vander, 1710) explained biological functions in physical and mathematical (“iatromechanical”) terms.

⁷⁴ “chartam hoedinam”; literally, “paper made of kid”; though Sauvalle, a contemporary of Malpighi, translates “feuille de papier”, “vellum” seems correct.

⁷⁵ The fluid under the blastoderm in the earliest stage of embryonic development of the chick. Harvey was the first to use “colliquamentum” in this sense; to him, it was the “radical, primigenial moisture” which nourished and formed the chick. He described the process in ch. 17 of his *De generatione animalium*, transl. Gweneth Whitteridge, Oxford, Blackwell Scientific Publications, 1981, where earlier similar observations such as Aristotle’s are discussed. Malpighi too used the word in the same sense in his *De formatione pulli in ovo* (1673) and

elsewhere; see Adelman, op. cit., note 1 above, vol. 2, p. 953, where blood vessels appearing in the colliquamentum are described. Sauvalle gives “mole”: not a correct translation.

⁷⁶ By “but” (tamen) I think Malpighi indicates that an external vessel is not so well placed as an internal one to vascularize polyp inside, in the aortic lumen.

⁷⁷ Malpighi’s extensive work *Anatome plantarum* was first published in 1675–9, with his *De ovo incubato* (London, John Martyn), i.e. about ten years after the first publication of *De polypo cordis*. Its second part is entitled *De plantis qui in aliis vegetant*, and considers plants growing within other plants (mistletoe, fungi, etc.); it also mentions animals growing within other animals.

⁷⁸ See note 42 above.

⁷⁹ Heinemann refers to the blood thus surrounded being “stagnerende”, but this is not in the Latin.

this will seem remarkable and significant⁸⁰ to anyone who diligently dissects animals, and studies the painstaking work of Nature, both in morbid tumours and in creating the structure of organs; for her pattern is generally the same. For instance, I recall finding that an iron needle, on its way out from the fleshy stomach of a hen, was invested with a strong double membranous covering, and a coating of fat as well. It is hard to believe that all this occurs through mere physical motion and necessity,⁸¹ without any influence acting for the animal's benefit.

Similarly, in certain tumours of the lungs, liver, and elsewhere, numerous integuments or bladders progressively build up, one outside another, and the accumulation of similar growths can be regarded as polypous in nature, for presumably the material and mode of production is comparable.⁸² Numerous layers can develop from a network of threads, in accordance with a normal law of nature. Then, if what lies between the threads is watery incoagulable ichor, such as abounds in this sort of tumour, the layers can remain separate all round. A part of the blood probably leaves its normal channels and vessels, and is at once slowed down by having to follow a new path; it comes to rest, and somehow gets anchored, along with fresh particles as they arrive, and is moulded together by the forceful pressure of the parts it meets. Meantime, its lighter and more spirituous⁸³ parts find their own way past, and the white fibrous particles remain; the red and other particles, which are less entangled, escape. The new channel thus opened releases blood less readily than before into the venous branches; hence blood enters it with a swirl, and congestion occurs round the original nucleus, where the fibres similarly get becalmed and entangled, so forming a coat; as they unite more closely together, the serum is squeezed out, and part of it moves inward. Thus, with the continuing inflow of blood, fresh layers continually form, as the white fibres already incorporated in the coats attach other similar fibres.

All this may be confirmed by examining shed blood which has congealed. The whole exhibits an interlacing assemblage of coats, one inside another, like an onion. And the structure grows more solid, as the mesh containing the red atoms and the serous part of the blood becomes tighter. The ichor is squeezed out; and thus, with the passage of time, the condensed mass of fibrous blood grows hard and compact, because the weave becomes closer, like that of skins.

The formation of Polyps attends particular diseases; Severino, drawing his information from dissection of cadavers, reports that they are common in those who have suffered from venereal disease, but he calls them "white phlegm".⁸⁴ I have twice seen notable

⁸⁰ "nec levia haec mirabitur, qui . . ."; Sauvaille: "ces petites remarques paroissent extraordinaires à ceux qui . . ."; Heinemann: "Als nicht belanglos wird der diese Erscheinungen bewundern, der . . ."

⁸¹ "sola materiae necessitate, et motu". The same thought ("sola materiae necessitate, nullo intercedente naturae fine") occurs elsewhere in Malpighi's work; see Heinemann, *op. cit.*, note 59 above, p. 9.

⁸² The Latin sentence is very tortuous and uncertain grammatically, reflecting perhaps an unclear thought: "ita in quibusdam tumoribus in pulmonibus, hepate, et alibi excitatis circumvolutiones seu multiplices vesicae, quarum amplior minorem continet, et ita successive coagmentantur, consimilium tumorum, conglobatio ad Polyposam naturam reduci

potest, cum eadem probabiliter materia, et productionis ratio in utrisque consimilis est . . .".

⁸³ "spirituosiores"; Sauvaille: "spiritueuses"; there is still vital spirit lingering in blood, and Heinemann's "gasförmig" is too modern; the word "gas" had not long been minted by van Helmont.

⁸⁴ Marcus Aurelius Severinus, (1580–1656; professor of anatomy and medicine at Naples; "wrote the first treatise of comparative anatomy" (F J Cole) *De abscessuum recondita natura libri VIII*, Leyden, Kerckhem, 1724, bk 4, ch. 2, section 4 (wrongly numbered section 3), p. 323. This is a mere single sentence, stating that Nicolaus Massa (1485–1569) dissected some syphilitics and found the veins contained more white phlegm than blood. Malpighi in

Polyps in the hearts⁸⁵ of men unexpectedly smitten by fear. I recall too an invalid, otherwise sturdy enough, who through fear fell a victim to unevenness and feebleness of the pulse,⁸⁶ especially at the left wrist, but with no marked recurrent dyspnoea, and no fever.⁸⁷ Before long, however, he spat up at times some red blood, and at other times plentiful white fragments like Polyps; and finally perished of suffocation, his upper parts swollen with pent-up blood. Similarly in apoplexy, as many observers report,⁸⁸ Polyps collect in the larger and smaller vessels traversing the meninges. In cardiac syncope, which very closely resembles apoplexy in its symptoms, they readily appear in profusion in the heart and lungs.

An eminent and intimate friend of mine, Silvestro Bonfigliuoli,⁸⁹ has just recently observed this in a young Florentine, who suddenly lost the power of sensation and motion, and presently passed away. At the dissection, Polyps sprouted out in both ventricles of the heart, and the whole substance of the lungs was found so crammed with white fragments as to be extremely heavy. The corpses of pleuritics contain many, not only in the heart, but also in the liver, and on the venous side;⁹⁰ the same finding is familiar in the wasted,⁹¹ and in some asthmatics; also in those whose glands (especially the conglobate glands)⁹² are so indurated that the animal economy is deprived of their contribution, as I recently found in a young woman. Her menstruation had always been suppressed, and the pancreas, and the other smaller glands scattered in the abdomen and thorax, were notable for their swollen compact material and were indurated. There were Polyps in her heart, and water had pooled in the middle and lowest body cavities. I have seen a like condition in a girl; under the stomach, beside the pancreas, and throughout the abdomen, were bunches of glands, like walnuts. In the heart were globules like filberts, of matter like plaster of Paris, and Polyps lay there as well.⁹³ I pass over fevers, the plague, and other distressing diseases arising from contamination of the air or ground, in which Polyps form, as the corpses of their victims prove.

From these and similar cases, we may surmise that Polyps appear when the mass of blood loses part of its proper fluid nature, and some particles (the white ones) precipitate, which are perhaps heavier than the rest, or can become so by combining and aggregating together. Structures then emerge which are moulded by the adjoining surfaces and by the remainder of the blood, into the form of what we term Polyps. Probably the fibres which

his *Opera posthuma* (note 4 above, p. 44) repeated the connection with venereal disease, and added melancholy as a predisposing cause, also excess of “coagulative acid salts”, and lack of “volatile particles transmitted by the air”.

⁸⁵ “praecordiis”: see note 27 above.

⁸⁶ “pulsus inaequalitatem, ejusque obscuritatem”—“pulse uneven and hard to feel” with Sauvalle, not Heinemann’s “unaufgeklärter Unregelmässigkeit”.

⁸⁷ “absque febre, et recurrente respirandi difficultate insigni, sed brevi tandem per sputa . . .” —unlike Heinemann, I think that “absque” applies to the respiratory difficulty too, and unlike Sauvalle, I think that “brevis” here means “soon”.

⁸⁸ Tulp (see note 2 above), and also for instance John Jacob Wepfer, *Exercitatio medica de loco*

affecto in apoplexia, Amsterdam, Janssonio-Waesburgii, 1724 (original preface dated 1658), p. 184.

⁸⁹ Or Silvester Bonfiglioli (1637–96). A skilled dissector, he was a pupil of Malpighi at Bologna about 1660–2 and remained his life-long right-hand man and correspondent. He became a museum custodian at Bologna. (Adelmann, *op. cit.*, note 1 above, p. 257.)

⁹⁰ “venoso genere”.

⁹¹ “tabidis”.

⁹² See note 103 below.

⁹³ “gypsea quasi materia”, hydrated calcium sulphate; it may be that “in corde globuli” means globules not within the heart’s lumen, but within the substance of the heart muscle, i.e. calcifications.

are so readily seen originate from tiny threads, as is found to occur in many cases of precipitation,⁹⁴ and particularly in that of crystals, where the microscope reveals that even the tiniest crystals exhibit the same shape as the mass created by their aggregation, which the naked eye can easily see.⁹⁵

Besides the white fibrous particles already mentioned, which are the initial fine framework of the blood and give it its particular substance, there are in blood reddish particles, so tiny that they are embodied in its liquors, and persistently remain wherever they are.⁹⁶ Also there are melted salts, with other similar materials which are constituents⁹⁷ of special ferments of the viscera; and finally a quantity of serum, of which the bulk is converted by heat into a substance with a pleasant taste, while the remainder dissolves into a watery and salty humour. These constituents are detected according to the laws of nature, as we can perceive through our senses⁹⁸ after a rough analysis. Since most of them tend of themselves to be solid and precipitated, Nature probably employs remarkable ingenuity in contriving fluid mixtures of them, in which such diverse constituents of blood, usually independent, tolerate being rolled out of small adjoining spaces,⁹⁹ and do not become precipitated, entangled with each other, and solidified, through close contact and involvement with unlike neighbours.

A major contributor to this outcome is the movement¹⁰⁰ of the blood through the vessels, over which the heart continually presides. This movement drives along and stirs the tiny slippery filaments which are mixed with the rest, especially with the red atoms; this can be deduced by watching frog's blood run out through transparent vessels. When the movement stops on the animal's death, the blood still appears liquid; but if its structure is examined, it looks like a muddy fluid, and tiny globules are mixed with the serum, as is revealed by the rich dark colour, typical of close-set red particles.¹⁰¹ Cheese and curds

⁹⁴ Heinemann's note here raises the possibility that Malpighi could see blood platelets (2–4 μm in diameter, and colourless), but since red cells, two to four times larger, and coloured, were seen only with difficulty until the compound microscope was markedly improved in the early nineteenth century, this seems unlikely.

⁹⁵ Note the difficulty in understanding how anything could originate from anything other than a miniature of itself. The belief that blood, since it clots, must even when liquid contain tiny fibres can be traced in Galen (Περὶ τῶν τῆς ψυχῆς ἡθῶν (Quod animi mores corporis temperamenta sequantur), ch. 6 (Kühn, vol. 4, p. 792): τὰς δὲ καλούμενας ἰνας αἷμα τὸ μὲν ἔχει, τὸ δὲ οὐκ ἔχει . . . δι' ὅπερ οὐ πήγνυται: some blood has the so-called fibres and clots; other blood (e.g. blood of deer) lacks them and does not.) Like Malpighi's mentor and friend Johannes Alphonse Borelli (op. cit., note 73 above, pt 2, ch. 8, Propositio 132, pp. 166–9), Johannes Bohn (*Circulus anatomicophysiologicalicus sive oeconomia corporis animalis, dicatus D. Marcello Malpighio*, Lipsiae, Gleditsch, 1686, p. 187) noted that fibres in liquid blood would block flow through the capillaries, but Malpighi did not accept the point; see his op. cit., note 4 above, p. 45, where he felt that the fibres in

liquid blood must be very small and "sero confusae".

⁹⁶ I.e. do not precipitate; in fact, given enough time, and provided that coagulation is prevented, they do precipitate.

⁹⁷ "constitutiva" (adjective). Souter gives "confirmatory, defining", and the *Thesaurus linguae latinae* "ad definitionem idoneus"; Sauvalle: "qui composent la nature des levains".

⁹⁸ "sensu"; Sauvalle guesses which sense: "sans artifice en la touchant seulement du bout de la langue".

⁹⁹ "circumvolutionem ex adjacentibus aliquibus spatiosis".

¹⁰⁰ "localis . . . motus"; Sauvalle: "mouvement local". In Aristotelian terminology, even a qualitative change is a "motus", and a change of position thus requires the adjective "localis".

¹⁰¹ It is upon this passage that Malpighi's claim rests to have been first to see red blood corpuscles; for discussion see Heinemann, op. cit., note 59 above, p. 21, where the competing claims of other passages in Malpighi's works and of other investigators are reviewed. Adelman (op. cit., note 1 above, vol. 1, p. 267) errs in reporting her as concluding that Malpighi did not see red corpuscles; she wrote: "Dass Malpighi auch die roten Blutkörperchen *gesehen* [her italics] hat, unterliegt

show an analogous state; their substance is coagulated in smallish globules, and then it requires manual pressure, or its own weight within a vessel, to expel the intervening serum, and produce in the end adhesion into a solid body. The fluid constitution of the blood is aided by the particles' own internal movement, analogous to that in individual fermented liquors. This movement causes enough overall disturbance to break everything into fine fragments, and to set in motion the more vigorously mobile particles. These latter, steadily and continuously emerging, and ceaselessly active, maintain the independence of each constituent, and the compatibility¹⁰² of diverse components. From certain cases previously described, it seems probable that this fermentation either is brought about, or is encouraged, by the liquors and juices separated or filtered by the glands, and particularly by the conglobate glands.¹⁰³

Finally, we may properly believe that Nature, in her concern to secure this fluidity, carefully incorporates and mixes a subtle but highly active principle, to produce by its motion and form both the mixing of the above-mentioned constituents of the blood, and their tendency to roll along.¹⁰⁴ This seems to me to be the conclusion reached by the perspicacious Tommaso Cornelio in his 'Progymnasma 7 de Vita'; he not only deduced but actually perceived a most subtle vapour in blood. There arises from gore, while it is still hot, a vapour of this sort, with a sharp salty tang, which impinges on the palate and tongue. He felt that it should be named the salt or balsam of life, since to it are due the free flow of the blood's particles, and the vigour of the rest of the body.¹⁰⁵ The central fermentation¹⁰⁶ extracts this salt of life, with the help of the lungs, either from the liquors

keinem Zweifel . . .". However, Malpighi provided no drawing of what he saw, and was soon overtaken by the vastly more detailed illustrated studies of Leeuwenhoek (August 1673 onwards), of which he himself became aware later (Malpighi, op. cit., note 4 above, pp. 41 and 162). Hence there is no mention of Malpighi when the shape and size of red blood cells were first properly established (Dr (Thomas) Hodgkin and J J Lister, 'Notice of some microscopic [*sic*] observations of the blood and animal tissues', *Philosophical Magazine*, 1827, 2, no. 8, 130–8.) Malpighi's claim is also discussed by Pericle di Pietro ('Marcello Malpighi e la Scoperta dei globuli rossi', *Bolletino della Società medico-chirurgica di Modena*, 1961, 61: 1–5). The technique most likely to shed further light on such points is "Practical History", repeating the original observations so far as is feasible; see Edwin Clarke and J G Bearn, 'Practical history, the role of experimentation in medical history', in Edwin Clarke (ed.), *Modern methods in the history of medicine*, London, Athlone Press, 1971, pp. 194–210, and J M Forrester, 'An experiment of Galen's repeated', *Proc. R. Soc. Med.*, 1954, 47: 241–4.

¹⁰² "congrua societates".

¹⁰³ Conglobate glands are lymph nodes; they were the topic of the last work of Malpighi to appear during his lifetime (*De structura glandularum conglobatarum consimiliumque partium epistola*, 1689), but his studies on them began a year after the

publication of *De polyo* (Adelmann, op. cit., note 1 above, p. 327).

¹⁰⁴ "ad volutationem dispositio". In his previous work on respiration (*De pulmonibus observationes anatomicae*, Bologna, Ferronii, 1661) Malpighi advocated mechanical mixing of the constituents of blood as the function of the lungs, and established by microscopy that blood proceeded from fine branches of the pulmonary arteries into fine tributaries of the pulmonary veins without emerging into the substance of the lungs—i.e. that there were pulmonary capillaries. He now supposes a further function: the uptake of a "vapour" from the air. For a full account of the growing understanding of respiration at this time, see Robert G Frank Jr, *Harvey and the Oxford physiologists*, Berkeley, University of California Press, 1980, especially chs 5, 6 and 8.

¹⁰⁵ Tommaso Cornelio (1614–84?) was a pupil of Severino at Naples, and became professor of mathematics there in 1654. He also reported in the same *Progymnasma* (one of his *Progymnasmata physica*, Naples, Raillard, 1668) that blood tasted sweeter after clotting than before. To use the sense of *smell* for detecting this "subtle vapour" was a novel idea, but not unknown elsewhere; Boyle (see Frank, op. cit., note 104 above, p. 185) proposed in 1664–5 to investigate the difference between arterial and venous blood by colour, taste, odour, heat, volatility and specific gravity.

¹⁰⁶ "fermentatione media"; Heinemann's "Vergärung mittleren Grades" seems less plausible.

Malpighi's De Polypo Cordis

that run with the blood (especially lymph), or, as I prefer to believe, from the external air. The lungs resemble a gland in their structure, and probably contain pores through which small bodies (formerly called particles of animal spirits) mix with the passing blood. These small bodies dilute, stir up and mix the juices passing along the vascular networks, and thus stir up the red part of the blood; for where the polypous crust is plentiful in gore, little is seen of the red, and where the red is plentiful, the crust is scarce.

This theory is supported by observation of the weather; for when the wind is northerly, pleurisy comes on very easily, from the clogging or blocking of the pores for this salt. And what is pleurisy, apart from the acute fever?—in a word, it is the deposition of polypous concretions in the lungs, as is clear from examination of the cadavers, and from the removal of the blood. Eminent authorities hold, I believe, that in such weather more nitre than usual gathers,¹⁰⁷ and mingles with the blood, causing it thus to set and congeal. But I am sceptical, because no visible change was produced by infusing six ounces of nitre solution into the jugular vein of a none too sturdy dog, except a diuresis, and the dog is still well.¹⁰⁸ Hence it seems unlikely that any clotting of the blood resulted, such as follows some injections of aqua regia.¹⁰⁹

In the above-mentioned disease states that give rise to Polyps, it is reasonable to hold that Nature's devices for the fluidity of the blood (as we ignorantly call them) are frustrated; the proper fermentation fails at times, and the constituents are not sufficiently refined to fit each position, nor are the more vegetative particles activated.¹¹⁰ Indeed, an abundance of polyp-forming material is an everyday finding whenever fermentation is not completed, through failure of the responsible organs, especially the glands and lungs.

The cause of Polyps ought not to be restricted to the conditions already mentioned. For Polyps are found to occur when certain poisons are drunk and in the mortal fevers due particularly to contamination of the air, and in the plague and other illnesses due to harmful contagion. In these cases it is likely that vapours, or abnormal juices, from perverted ferments in the organs find entry to the blood, tamper with its structure, and create a new form of solution and interaction¹¹¹ of its particles. They can remove the bonds by which the tiny fragments of white fibres are held suspended and linked to different material. Or else, as if they had hooks, they bind the suspended fibres together into a fine network or cluster, which precipitates. While the network is being carried along by the flow of the still fluid remainder of the blood, it may reasonably be expected to

¹⁰⁷ This was originally sodium carbonate, which was to Boyle "Egyptian nitre", while to him "common nitre" was potassium nitrate, i.e. saltpetre (Partington, *op. cit.*, note 68 above, p. 539.)

¹⁰⁸ This is among the first intravenous injections ever performed, and priority is credited to Malpighi by Haller; for details see Buess's review (Heinrich Buess, *Der Historischen Grundlagen der intravenösen Injection*, Veröffentlichungen der schweizerischen Gesellschaft für Geschichte der Medizin und der Naturwissenschaft XV, Sauerländer, Aarau, 1946.) Malpighi's pupil Carlo Fracassati had published more extensive results of intravenous injection the year before *De polypo cordis* appeared. The experiment here so briefly described is notable for its quantification of the dose, for its correct result

(saltpetre is in fact diuretic), and for the competence which enabled the dog to survive. Even more brief, and less adequate, is the probably earlier reference in Robert Boyle, *Some consideration touching the usefulness of experimental naturall philosophy*, 2nd ed. (1st ed. 1663), Oxford, for Ric. Davis, 1664, pt 2, p. 55: "And in Diureticks a very ingenious Anatomist and Physician told me, he tried it [intravenous injections into a dog] with very good success."

¹⁰⁹ Four parts of hydrochloric acid with one of nitric acid; dissolves gold, but not silver.

¹¹⁰ "vegetatiore" ("vigoureuses"—Sauvalle) *particulae non exaltantur*: "exaltatio" is an alchemical term indicating the enhancement of activity (Partington, *op. cit.*, note 68 above, p. 253).

¹¹¹ "attritio".

become readily entangled in the recesses and irregular prominences of the chambers of the heart, or in the bifurcations of the vessels; there it is compacted by the ceaseless impact of the remaining blood, as occurs in rivers.

Under conditions¹¹² such as I have described, I am aware that reputable authorities hold that the blood of the victims turns sour like milk, and hence clots through the great preponderance of acid. This and similar problems can be much illuminated by experimental infusions, which have, I know, often been administered by men of learning and skill; however, to avoid the difficulties and uncertainties of injections,¹¹³ and to contrive an easily visible experiment, I made additions to blood still warm, before clotting occurred, and looked for results in the form of precipitation or of increase in firmness or softness. The addition of oil of sulphur¹¹⁴ produces swelling of the portion it touches or overlies, which in the end gets cooked, turns black, and forms a solid crust. Oil of vitriol gives the same effect.¹¹⁵

Powdered alum,¹¹⁶ sprinkled onto blood which is still liquid, turns it black, and makes it look burnt. Nitre,¹¹⁷ either powdered or in solution, on being added to blood produces a thin substance more red than purple;¹¹⁸ so do aqua vitae,¹¹⁹ ordinary salt, rock salt, sal ammoniac,¹²⁰ sulphur, and hartshorn; all these seem for a short time to prevent clotting of the blood.¹²¹ So, if one is to theorize from these and similar instances about the causes which in the plague etc. produce Polyps and congeal part or all of the blood, then the appropriate analogies are alum, vitriol, and the like. Nitre, volatile spirits, and hartshorn are excluded, for they serve better as remedies, to reconstitute¹²² and liquefy the blood.¹²³

On the topic of Polyps, my pen has outrun its original intention; for it has long been the case with blood, that it is always a fertile producer,¹²⁴ yet wearies the mind of mortals, because their own knowledge is so barren.¹²⁵

¹¹² "constitutiones".

¹¹³ Buess, op. cit., note 108 above describes these.

¹¹⁴ See note 64 above.

¹¹⁵ Oil of vitriol too was sulphuric acid, but made by distilling green vitriol (iron sulphate). Boyle knew that oil of sulphur and oil of vitriol were the same. (Marie Boas Hall, *Robert Boyle and seventeenth-century chemistry*, Cambridge University Press, 1958, p. 116).

¹¹⁶ This is probably potash alum, which was used in dyeing, and so there was a vast empirical knowledge of it. It is a general precipitant of proteins, and hence denatures blood.

¹¹⁷ See note 107 above.

¹¹⁸ "purpura rubicundiorum"; Sauvaille: "plus rouge qu'écscarlatte", whatever that means.

¹¹⁹ Spirit of wine, alcohol.

¹²⁰ Ammonium chloride.

¹²¹ For details of the century of ultimately sterile similar experiments that followed see Manfred Lindenberger, *Pharmakologische Versuche mit dem menschlichen Blut im 18. Jahrhundert*, Berlin, Institut für Geschichte der Medizin und Naturwissenschaften, 1937. I am indebted to Dr Maehle for a copy of this inaugural dissertation.

¹²² "refermentando".

¹²³ Liquefying the blood was the aim in treating cardiac polyp, and also for example amenorrhoea (see John Freind, *Emmenologia*, in his *Opera omnia medica*, London, John Wright, 1733, p. 140).

¹²⁴ "foecunda rerum productione indies polleat"; producing what? Sauvaille thought it produced "beaucoup à penser" and in addition "de nouvelles productions et de nouveaux phénomènes"; Heinemann: "fruchtbaren Hervorbringung von Dingen". No doubt the diverse products of coagulation are meant. Compare the remark earlier in the present treatise: "There is in blood no lack of slumbering seeds of several things."

¹²⁵ Heinemann's footnote indicates that she regarded "propriae scientiae" here as "of knowledge about oneself", but the translation given seems more straightforward. The thought strongly recalls the peroration of Malpighi's *De omento, pinguedine et adiposis ductibus* (in the *London Opera omnia*): "Suspecta tamen esse solet, humani ingenii fecunditas, quae dum verum, et unum non attingit, pluribus superabundat"—the fertile human mind is often distrusted; overflowing with ideas, it misses the one true one.