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**KNOWLEDGE AND SPECIALISED TRADES IN THE LATE ANTIQUE WEST:
MEDICINE VS ENGINEERING**

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KNOWLEDGE AND SPECIALISED TRADES IN THE LATE ANTIQUE WEST: MEDICINE VS ENGINEERING

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Abstract

The high degree of specialisation achieved in the Roman world covered a vast area of trades and reached beyond economy and production into specialised knowledge and science, but in the transition to the Middle Ages large parts of this knowledge were lost. The continuity and end of some specialised trades which were common in the early Empire but which were rare (or disappeared) in late Antiquity can be seen through the material and written record. In this paper, we aim to explain the divergent evolution of two such professions (medics and engineers) in the western provinces, adding more examples and further case-studies to current debates. Whereas medics and medicine continued as a profession, in part through the protection of the Church, specialised engineers and architects (which were usually linked to state training and employment) seem to have disappeared, together with the state structures that supported them.

Key words: Late antique science, Gaul, Spain, Medicine, Engineering

Introduction

The transition of Classical ancient science into the late antique period and beyond – in particular the continuity of technologies and techniques – is an area of research that attracts increasing interest among scholars. It is, however, difficult to distinguish in the ancient world between pure science from religious and philosophical thought. The very same field of knowledge can also be easily confused with popular wisdom or even with folklore. We will avoid as far as possible making such distinctions and consider instead the entire body of knowledge used by the elites.¹ Whereas it is true that the preservation of Classical technical texts to the present day is an indicator of the continued interest in ancient science, this may further suggest a long-lived interest in such technical knowledge from a theoretical or literary point of view, the extent to which this happened in a more practical, hands-on way is far more difficult to prove. With this in mind, we would like to join the ongoing debate by examining several particularly telling case studies from the late antique and post-Roman West that will shed light on medical and engineering knowledge.² With this focus on the sciences of engineering and medicine we exceed our own

¹ Cf. Riddle 1987; Lloyd 1983.

² We will be using ‘engineering’ (and engineers) in preference to ‘architecture’ as the general term to refer to the overall concept of specialised and skilled building, architecture, and design of constructions in civil engineering and other large public projects.

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areas of expertise. However, we hope to be able to plausibly justify our decision to venture into these areas on the ground that these bodies of knowledge and their different evolutions reflect not only specialist fields but also two main ideas about the Romans in popular culture in general: 1) the Romans are deemed the greatest engineers (knowledge which collapses with the ‘Fall of Rome’), and 2) the Roman tradition is responsible for perpetuating the longest-lasting corpus of Western medicine notwithstanding the fact that the medical tradition originated earlier in the Greek-speaking world.³ This comparative approach could perhaps complete and add to the general discussions of the decline of technical skills and knowledge, especially as presented in the volume edited by Luke Lavan *et al.* in 2008 on the transmission of Classical knowledge into late Antiquity, a volume which we do not intend to discredit or reject, because it has proven to be very useful and complete in its coverage. However, we would like to add the comparative element of medicine, which we felt was missing, plus we intend to add more Spanish material to the construction side of the argument to further test their proposals.

Our frame of reference is the late antique West, particularly Gaul and Spain, ranging chronologically from the 4th to 7th centuries. However, we will also be putting forward examples and comparisons from the East, where these practices continued much in the way they had done during the preceding centuries, linked to state patronage and urban, Roman elite culture.⁴ We hope that this contrast between continuities and ruptures will highlight the relevance of our particular case-studies. In order to do this, our paper is organised into three sections, addressing the degree of specialisation achieved in the Roman world, the transformations of the 5th and 6th centuries, and a general approach to changes in scientific transmission in this process. Overall, we want to suggest that while medicine was promoted by and benefitted from state intervention, its cultural and social reach went beyond it, allowing it to continue largely unchanged into late Antiquity and into later periods, whereas engineering was too closely linked to the Roman state apparatus to survive its demise.

An over-specialised Rome

The scientific and technological culture of the Roman Empire was characterised by a high degree of over-specialisation, and this is visible in many aspects of life. We could briefly introduce two examples from material culture which have been for years used as evidence to underline this process. We are referring to the production of finewares and mosaics, which are common and widespread, and at the same time very specialised and far-reaching. Samian wares (Arretine, Gaulish, Hispanic, and African red slips or *terra sigillata*) are characteristic examples, to such an extent that they flooded the market and almost completely eclipsed local productions between the 1st and the 5th centuries CE.⁵

³ Romans are not seen as scientists and intellectuals like the Greeks, although they were responsible for preserving and developing the Greek tradition. This is a broad-brush simplification, but it needs stating. Biology (e.g., Pliny the Elder) versus Astronomy (Hypatia) would be also viable comparisons of continuity and decline, but perhaps more limited in terms of examples and later impact.

⁴ Cf. Cuomo 2007: 131-45; Garofalo and Roselli 2003.

⁵ In the case of pottery, large scale production was key; this wide distribution was partly enabled by the Mediterranean Roman peace and the state sponsored trade through the *annona*.

Regarding mosaics, certain patterns and motifs such as marine scenes were produced throughout the West with a very small range of widely-distributed copybooks.⁶ This very high degree of specialisation in trades (potters, mosaicists) applied also to other disciplines not only practiced but also discussed and theorised by classical authors.⁷ And this same level of expertise was also achieved in building and in medicine.

In medicine, a high degree of specialisation was achieved in various ways. Roman surgical instruments, for example, established a series of typologies which have only been updated or substituted in the 20th century (fig. 1). Gynaecological instruments retrieved from various archaeological excavations, and the depictions of other, more generic, medical instruments at the Kom Ombo temple of Sobek in Egypt provide a couple of good examples.⁸



Figure 1: Vaginal speculum found in Mérida and preserved in the National Archaeology Museum, inv. no. 32643. It is exactly the same as those found in Rome or Pompeii. Photograph © Javier Martínez and Patricia González.

Recipes for medical remedies can be seen as another good example. Some of these required very precise measures of highly specific and exotic ingredients that prompted an active, long-distance, specialised trade. Pliny the Elder (*NH* XXIX.8) complains that some of these recipes were outright scams and medics had to find ways to counter constant falsifications and adulterations.⁹ Medics also specialised in different branches,¹⁰

⁶ Walker 2016: 53.

⁷ Cf. Lavan *et al.* 2008.

⁸ Bliquez and Jackson 1994: 84 ff; Fuentes Domínguez 1987: 251-274; Jackson 1995: 189-207.

⁹ González 2016.

¹⁰ *Dig.* L.13.1.3.

and we find references to *medici chirurgi*,¹¹ *ocularii*,¹² *auricularii*,¹³ and *veterinari*.¹⁴ These distinctions appear also among female medics, who cannot be seen simply as specialised midwives, as we know of a female ophthalmologist¹⁵ and a *medica philologa*.¹⁶ While Galen was trained as a medic in a gladiatorial school (where he learnt much about anatomy), and Dioscorides through the army,¹⁷ there were also municipal medics paid by the councils.¹⁸ Similarly, wealthy families owned private medic slaves (as Elvius Severus in Pompeii), or could go to private independent doctors.¹⁹

As opposed to this diverse situation, civil engineering was directly linked to training through the army, and in this respect the expansion of the Roman state prompted the wide dissemination of trained engineers who could build roads, bridges, vaults and arches. Many times these large projects were promoted or funded by the central administration, but local elites during the early Empire were also very active, monumentalising their civic centres with theatres, amphitheatres, or baths. The widespread use of *pulvis puteolanus* (pozzolanic mortars, ‘Roman concrete’) beyond Italy and the development of precise measuring and surveying tools (such as the *chorobates* used by *libratores*, or the *groma* and *dioptra* of the *gromatici* or *agrimensores*) enabled, for instance, the construction of aqueducts with perfectly calculated gradients (down to 0.016 m/km in some extreme examples), or tunnels and roads carved into the rock, besides wonders of engineering such as the Pantheon or the large imperial baths in Rome and the provinces.²⁰ Besides the army, similar training was also offered through local apprenticeship systems in the civilian sphere, and the constant demand for their services meant that trained and skilled engineers existed all across the Empire, available to any of the grand building projects that characterised the early Empire (as famously exemplified in Trajan’s reply to Pliny the Younger in his *Epistula* X.40).²¹

As a discipline, however, Roman engineering and architecture have left very few traces in Roman writings: namely in Frontinus’ *De Aquaeductu* and Vitruvius’ *De Architectura*. Other classical authors, such as Pliny, discussed building as well in their more generic works. The problem with these treatises is that they were not handbooks to train new architects (at least Vitruvius’ is clearly not), but more of a theoretical work for aristocrats who may be involved in building projects as part of their career. In this way, engineering was an element of elite literate culture, part of the expected list of interests of any aristocrat willing to go into politics or the army. Vitruvius (*De Arch* I.1) does mention, however, all the various skills and sets of knowledge an architect must master, including physics, mathematics, geometry (just as today), together with history, music and philosophy.

¹¹ E.g.: *CIL* VI.3986; XI.5400; *AEP* 1945, 62; 2001, 263.

¹² E.g.: *CIL* II.5055; XI.742; *AEP* 1994, 840; 1979, 572.

¹³ E.g.: *CIL* VI.9608, 8908, 37752; XI.5400.

¹⁴ E.g.: *CIL* V.2183; VI. 9611, 9612, 9613, 37194.

¹⁵ Alonso 2011: 267-296; Buonopane 2003: 113-130; Dana 2014: 21-41.

¹⁶ Naevia Clara, *AEP* 2001, 263.

¹⁷ Cic. *Tuscul.* II. 38; 7; Suet. *Caes.* XLI.

¹⁸ Usually between 10 and 15: Filippis Cappai 1993: 86 ff.

¹⁹ Berg 2003: 131-154.

²⁰ Adam 1994.

²¹ *Nulla provincia est, quae non peritos et ingeniosos homines habeat* – “There is no province which lacks skilled and clever men”.

This sharply contrasts with the available corpus of Graeco-Roman medical texts, which range from reference book for medics (e.g., Dioscorides, *De materia medica*, or the Hippocratic corpus) to student handbooks (e. g. Celsus, *De medicina*, or Soranus, *Gynaecia*). Some of them, such as Galen's *De usu partium*, were in use well into the Early Modern period. These were specifically aimed at medics or medical students. Similarly, academic texts more widely circulated, such as Pliny's *Naturalis Historia*, compiled a wide range of pharmacologic information, and were aimed at a larger educated audience. In parallel to this, there were various minor texts and recipe compilations like the Merton papyrus (I.12).²² Galen himself describes in *De libris propriis* how he had written many letters to his friends with advice or information not intended for publication, which highlights the widespread use and diffusion medical texts could have.

What we have here are two examples of the high degree of professionalism that could be achieved through very different support mechanisms. It is nevertheless this economic over-specialisation that has been put forward as one of the reasons behind the collapse of the Roman imperial system.²³ What we are pointing out is that differences in the support mechanisms led to different outcomes when this collapse eventually happened. Once the circumstances that favoured the two professions mentioned changed, their later evolution depended on how adaptive they could be in the post-Roman world.

Politically, culturally and materially, life in 500CE was very different from what it had been in 300CE. Despite the wide-ranging degrees of regional variation, archaeological assemblages at those two points are very distinctively dissimilar. A completely different matter is whether these changes were for better or for worse, and judging it only through the material record is misleading. The question that we would like to put forward now therefore is how far this specialisation affected the continuity of engineering and medicine, especially on how the end of the system that favoured such a degree of professionalism affected their evolution, considering that they were built on such fundamentally different sub-structures as we have just outlined in this section.

Changing Circumstances: the 4th and 5th centuries

The State

The socio-political circumstances which favoured the high degree of specialization in the Roman period changed dramatically during late Antiquity. The three major changing circumstances that affected medicine and engineering were the state, the elites, and the Church. The most important transformation of late Antiquity was the collapse of the Roman Empire as a political system which put an end to all the state apparatus that had promoted engineering and medicine – the army in particular. However, the different scopes of state intervention, and the ideological and cultural interest in both areas (engineering being far more state-involved) can explain the diverging paths taken by these two sciences.

As we have outlined, the state was the main sponsor and the main source for training and employing engineers, both through the army and large imperial building projects. The demise of the former and the reduction of the latter limited the supply of and the demand

²² Andorlini 2010: 142-167.

²³ Cf. Heather 2005; Ward-Perkins 2005.

for such trained engineers. Throughout the 5th century, the increasing number of *foederati* in the army, who were not trained in the Roman fashion, reduced the pool of army-trained engineers.²⁴ Eventually, they ceased to be available completely in the West, and although this is itself not yet visible in the 5th century, it is evident in the constructions and designs of the 6th and 7th. In contrast, there is evidence from the East and the territories reconquered by Justinian in the West to suggest the existence of such specialists protected by the state.²⁵

Furthermore, whenever such skilled engineers appear outside the eastern Roman territories, it can be directly linked to imperial intervention. Three specific examples of requests for trained and skilled men from the emperor are known from Italy by the Ostrogoths and, later, by the Pope (*Variae* III.53; *RegEpist.* IX.4) and by the Avars in the Balkans (Eph. *HE* VI.24; cf. Men. *HF* XXV.1).²⁶ An archaeological example is the construction of the new aqueduct of Reccopolis (fig. 2) in central Spain by King Liuvigild in 578CE, which is too suspiciously unique to be considered the work of local builders – especially considering that it is the first entirely new urban aqueduct built in the West since the 4th century.²⁷ This aqueduct is linked to a whole new city, part of Liuvigild's



Figure 2: View of the aqueduct of Reccopolis, built in the late 6th century. It is the last aqueduct built in Roman technique in Spain, and the first *ex novo* aqueduct in the West built since the 4th century. It is linked to a whole new city, part of Liuvigild's policy of state formation and imperial emulation.

Photograph © Javier Martínez and Patricia González.

²⁴ Lee 2007: 12.

²⁵ Cuomo 2008: 29; *CodIust* X.66.1-2 = *CodTheod* XII.4.1-3.

²⁶ For the Balkans, see footnotes 174, 296 and 316 in the Blockley edition.

²⁷ Martínez 2015; Walker 2016:126.

policy of state formation and imperial emulation. In Italy, Theoderic was responsible for the reconstruction (Ravenna) and repair (Rome) of aqueducts,²⁸ but Ostrogothic Italy is quite exceptional in terms of continuity with the late imperial past, and even there, the two examples mentioned were repairs, not new constructions.

In the same way, the end of the army and state apparatus in the West prompted the end of a group of medical institutions which had been directly linked to it. Military hospitals (*valetudinaria*) seem to have disappeared by the 4th century, which coincides (without any obvious links of causality however) with the emergence of civilian hospitals. The latter had links with the pre-existing hospices for the poor (*paupere gymnasia*) and to the later hostels for pilgrims and poor, the *xenodochia*. These institutions were common in the East in the late 4th century, and they expanded into the West from the mid-5th.²⁹ Some of the largest ones, like those of Constantinople or Jerusalem, had over 200 beds and were remarkably specialised into various branches of medicine.³⁰ The relocation of specialised medical activity beyond the army and into charitable institutions (usually linked to Church sponsorship) meant that neither the concept nor the techniques of a hospital were lost once the imperial system collapsed in the West.

As the transformation of the *valetudinaria* shows, there are two different factors in medicine which set it apart from engineering: the first is the takeover by the Church of a certain degree of medical assistance. The second is that medicine was not only linked to the state; it was more generally spread.

Private initiative

It is above all in the private sphere that we find changing circumstances and attitudes towards medicine and engineering that further explain their diverting trajectories in late Antiquity.

For one, town centres were by the 4th century already full: once you have a theatre or an amphitheatre, there is no need to have a second one.³¹ Consequently, new building projects were more difficult to fit in the urban landscapes. Added to that, the post-Diocletianic municipal system did not encourage local elites to fund new constructions, as sponsorship of such constructions was now limited to the higher echelons of the imperial administration.³² This is not to say that private building ceased; nothing could be further from the truth. There is plenty of evidence to suggest that 4th and 5th century building activity in domestic and, to a limited extent, public contexts continued. But these were not constructions which required complex engineering calculations or designs (the work of ‘vernacular builders’),³³ and show an overall decline in the number and abundance of complex monumental building. And in those few cases where this was true, they all can usually be linked to main capital cities, or other towns with political relevance, where the local elites may have had an interest in preserving old building traditions. The continuity of aqueduct supply in towns into these centuries, for instance, had to depend on elite

²⁸ Coates-Stephens 1998; 2003.

²⁹ Menéndez 2013: 54 ff.

³⁰ Nutton 2001: 52-81; Horden 2012: 715-743.

³¹ Plus, these type of spectacles were already going out of fashion, so no new theatres and such were built in late Antiquity.

³² Liebeschuetz 1992.

³³ Cf. Lavan 2008: xxxix-xxx.

interest and constant maintenance, and could not rely on any major reconstructions or repairs.³⁴ Barcelona, Mérida, Tarragona, Valencia, Seville, Córdoba, Toulouse, Lyon or Narbonne are all good archaeological examples of aqueduct continuity into the 5th century (and later), and all were main political and economic centres, but in no case we see new aqueducts being built or any other large public of complex design or vaulting. In Gaul, we know of an aqueduct workman in late-5th century Vienne, but he was probably the last of his kind.³⁵ The systematic quarrying and dismantling of older structures, or the reuse of this building material in reduced wall enclosures were perhaps the most complex and daring construction projects of this period,³⁶ but they can still be chronologically linked to moments when the state apparatus was still functional in the provinces.

Whereas private individuals had been involved in engineering through either military duty or political incentive (two motivations that largely disappeared during the late Roman period), medicine had a much more personal component. This is easily understandable as it is an element of self-preservation. In fact, the *paterfamilias* had the moral and social duty to look after the health of his family.³⁷ This explains the existence of texts on medicine aimed at a non-professional audience already from the 1st c. CE, such as Soranus or Celsus mentioned above, together with family and domestic recipe books,³⁸ or the presence of references to medical authors in non-specialised texts (like such as Tertullian citing Herophilos).³⁹ Parallel family interests in engineering did not exist. At this level, there was an interest in construction as a topic in late dates, but this was more a reflection of intellectual discussions and general knowledge of the educated aristocrat – much in the tradition of what Vitruvius originally intended.

Professionally, the appeal of engineering and medicine in the late Roman period was very different, beyond the simple public demand. Engineers were males, who entered public service, held office or were in the military, and obtained their training through this state-sponsored system. Medics, on the other hand, could be found in all social strata. They could be slaves, freedmen, *ingenii*, even members of the upper classes.⁴⁰ There were also municipal medics employed by the councils, who could achieve a certain social status, but these were far from the standards of living of Roman aristocratic medics, such as Galen.⁴¹ Women, as it has already been said, also practised medicine, and they are becoming increasingly visible in the historical and archaeological records,⁴² not only for the Roman, but for later periods as well.⁴³ Furthermore, not only *medici*/ἰατροί were

³⁴ Martínez 2014.

³⁵ Gregory of Tours, *DLH* II.33: *expulsus est inter ceteros artifex ille cui de aqueducto cura manebat* – “amongst those who were expelled [from Vienne by the Burgundians] was the **workman** in charge of the aqueduct”.

³⁶ Seomnde Cleary 2013.

³⁷ This is already mentioned in Republican discourses against Greek medicine: Nutton 2004: 161ff; Scarborough 1970.

³⁸ Pérez Samper, 2012.

³⁹ Kitzler 2014: 204–209

⁴⁰ Pleket 1995: 27–34.

⁴¹ Filippis Cappai 1993: 86 ff; *Dig.* L.9.1; *CodTheod* XIII.3.1–5.

⁴² E.g.: *CIL* II.497; V.3461; VI.6851, 7581, 8711, 8926, 9614, 9615, 9616, 9617; VIII.24679; IX.5861, 6394; X.3980; XI.6394; XII.3343; XIII.2019, 4334, 5949. *AEp* 1937, 17; 1972, 83; 1974.192. *IG* XIV.1751.

⁴³ Berg 2003: 131–154; Dana 2014: 21–41; Buonopane 2010: 101–110; Buonopane 2003: 113–130; Cabré and Ortiz 2001.

trained in medicine; there were all other sorts of associated professions which required a scientific knowledge of medicine, such as *farmakopolai* and midwives.⁴⁴ Besides these, there were other sets of people with various interests in medicine, ranging from perfume sellers (*Antid.* I.5, 12, 14) to scholars such as Pliny the Elder or Celsus.

Lastly, another element to take into account is that medics were held in high social esteem;⁴⁵ it was a prestigious role to hold, while engineers did not find themselves in such positions. The existence of magistracies such as the Palace Architect or the City Architect in Ostrogothic Italy⁴⁶ are, firstly, linked directly to the city of Rome (which is in itself an exceptional case), and, secondly, most probably positions not for actual engineers, but rather for political supervisors. This difference in social prestige further alienated engineering as a cultivated and practised science.

The Church

Besides the private and public initiatives that protected and promoted medicine and engineering in the Ancient world, the Christianisation of Roman society and politics in late Antiquity lead to the emergence of the Church as a main agent of change. During the late Roman period, the Church acted mostly as a beneficiary of state intervention and pious private donations, and it was not until the 6th century when the bishops stepped up as leaders of their local communities.

Partly in their role as local leaders, bishops (although some lay donors are also known) built or repaired churches and episcopal complexes (or *xenodochia* as mentioned above), but these were all buildings of quite simple design (rectangular halls, and basilica-shaped churches with pitched, timber-framed roofs) which did not require vaulting or other complex calculations. In the 4th and 5th centuries, mosaic decorations and wall paintings were common in these buildings – but these luxury decorations respond to different patterns of production and consumption and their continuity has nothing to do with the preservation of engineering calculations or designs.⁴⁷ In the cases where more sophisticated structures were built in the 5th and 6th centuries, (like the heated room of the episcopal hall of Lyon, or the episcopal baths of Barcelona),⁴⁸ the possible explanation could be that these were two important cities (at a political and economic level), which would have been able to preserve better trained men. This could also account perhaps for the continuity of aqueduct maintenance in the most important cities of the Visigothic kingdom (like Mérida, Barcelona, Valencia, or Córdoba),⁴⁹ but these examples are rare enough to be considered unique exceptions. It is not surprising to see bishops, as political continuators of earlier *euergetes*, interested in the basics of construction so they could

⁴⁴ Scarborough 2006: 1-29; Teoph, *HP*, IX, 18, 4; Repici 2010: 73- 90; King 2002: 172 ff; Flemming 2007: 257-279.

⁴⁵ Medics had, regardless of the social status, a degree of authority over their patients – even slaves over citizens. This may be behind the requirements of public medics to have a proven moral virtue and only the necessary medical knowledge: Geyer-Kordesch and French 1993. This caused equals amount of fear, criticism and respect.

⁴⁶ *Variae* VII.5 and VII.15.

⁴⁷ They become, furthermore, increasingly rare beyond the late 5th century, excepting for main imperial western foci such as Ravenna or Rome.

⁴⁸ Le Mer and Chomer 2007: 460-7; García-Entero 2005: 213.

⁴⁹ Sanchez and Martínez 2016.

supervise construction projects themselves,⁵⁰ even if these did not involve any major mechanical or engineering challenges.

Whereas church building can be seen as an incentive that permitted the continuity of large-scale basic construction projects (even if done by vernacular builders), the popular imagination has tended to see the Church as hindering the advance (when not actively acting against) of scientific development. As we can see in the evolution of medicine, however, this is clearly not the case. In fact, through buildings such as hospitals and *xenodochia* bishops were playing a significant role in the preservation of a large corpus of active and practiced medical lore.⁵¹ The active copying of scientific manuscripts and the direct interest in the works of medics contributed to the preservation and transmission of medical science. Even elements considered questionable or immoral were copied without hesitation, as it can be seen in the frequency and lack of censorship in texts about abortion or birth control.⁵² Similarly, later institutions linked to science and medicine such as the Medical School of Salerno or universities emerged out of ecclesiastical sponsorship. Even Hildegard von Bingen, who wrote directly to monastic communities in Germany, showed an interest in folk medicine (which has a Galenic base); an example of how widespread this knowledge was in the later Middle Ages and an active intention in preserving it.

Diverging paths: continuities and ruptures beyond late Antiquity

The way engineering and medicine survived as disciplines into the Middle Ages varied greatly, with two very different (nearly opposing) outcomes. Whereas medicine was preserved as a science, cultivated and further developed, complex and technical engineering died in the West together with the early Roman construction habitus which had prompted it in the first place.

Transmission of knowledge

The preservation of knowledge required the training and teaching of new generations of scholars, but also of practitioners. This could be done by generating literature to spread the knowledge or, more usually, by apprenticeship systems to train and teach. In late Antiquity, however, these channels of transmission were disrupted, and for engineering and medicine two diverging paths emerged.

Texts and discussions in medicine continued to be produced and compiled, as briefly mentioned above. There are, however, hardly any references to technical works, and none on building or engineering. Although a certain degree knowledge of architecture is preserved amongst the educated elites, it seems this was more an element of the

⁵⁰ Gregory the Great, *RegEpis* V.53.

⁵¹ Van Minnen 1995.

⁵² Noonan 1969: 262ff; Sánchez del Bosque 1988; Christin-Maitre 2013. Medieval text censorship did exist, but not just in Christian manuscripts, and surprisingly not often in medical texts: for example, Arab translators sometimes omitted Galenic references to divine nature, and Gregory IX had some fragments of Aristotle which could be taken as directly against Christian principles deleted from corpora in Paris (French 1979, 1994).

aristocratic education rather than an indication of interested purposeful learning.⁵³ In fact, Vitruvius' impact on late antique writers is quite limited (only epigrams through Faventius or Pliny the Elder appear in late antique texts), and as such it is absent from the *Etymologiae* of Isidore of Seville, perhaps the only major text from the late antique West dealing with building and engineering to any extent.⁵⁴ Frontinus' *De Aquaeductu* may have been available to him, even if partial or in epigrams, as Isidore's description of pipes and hydraulics follows closely this text. With medicine, however, not only were new texts being written, but also texts that compiled the large volumes of Roman medical literature, something which should be understood as an attempt to rationalise and synthesise the Galenic corpus rather than to substitute or reduce it. Late antique encyclopaedists and medics such as Aetius, Oribasius, Paul of Egina or Marcellus Empiricus carried out these compilations, which would create a corpus that would endure into the Middle Ages and beyond.⁵⁵ A perfect example of this is anatomy, which would only go beyond these Galenic canons (and pseudo-Galenic works such as *De Iuvamentis Membrorum*) with the revisions and researches of Vesalius in the mid-16th century.

The very nature of medicine had prompted the establishment of networks of interaction and professional exchange – something that was not easily applied to engineering without state intervention. There were various schools of medicine linked to temples (*asklepeia*, in particular that of Pergamon) where individuals would go and learn their trade, and this tradition of educational travel continued in late Antiquity (even if eventually disconnected from pagan sites).⁵⁶ In the same way that Galen in the imperial period travelled across the Mediterranean, Alexander of Tralles travelled from Lydia across the Mediterranean (including Spain) to further advance in his learning.⁵⁷ Personal initiative to re-settle and open new markets, as exemplified in the case of bishop Paul of Mérida (who had been a surgeon before becoming archbishop),⁵⁸ could also be behind the widespread continuity of medicine in urban contexts, in contrast with engineering knowledge and practice. This mobility was not limited to medical professionals; it was accompanied by the exchange of recipes, books, and the trade of ingredients – a tradition which continued beyond late Antiquity.⁵⁹ Even if there are some examples of Gaulish itinerant builders,⁶⁰ it is difficult to see these groups moving to set up a new 'business' in a new town; as opposed to what physicians and medics could do, builders probably moved where and if they were required.

Lastly we should mention apprenticeship-based modes of transmission, as they existed in the Roman world and continued into late Antiquity. In medicine these existed at both an organised and a more informal (even familiar) level, but this did not happen with engineering. The declining of demand for new constructions, together with the end of imperial training systems, lead to the end of engineering apprenticeships (besides the lack

⁵³ Cf. *Variae* III.52; Sidonius Apollinaris, *Epist.* VIII.6; Gregory the Great, *RegEpis* V.53.

⁵⁴ Kruft 1994: 30. Vitruvius appears again in the writings of Alcuin and Einhard (Krinsky 1967), and then his rules on proportion taken by later cathedral builders (Conant 1968).

⁵⁵ Andorlini and Marcone 2008: 60 ff.

⁵⁶ Wickkiser, 2008:39 ff.

⁵⁷ Frutos González and Guerrero Peral 2010; Vallejo Girvés 2002.

⁵⁸ *VSPE*, IV.

⁵⁹ Andorlini, 2010: 142-167; González Gutiérrez 2016. Some spices such as pepper were as common in kitchens as they were in pharmacies, and they travelled all along the Empire from India into Britain (Van Der Veen 2011: 41).

⁶⁰ Lebecq 1996: 298-9.

of evidence).⁶¹ There was, by contrast, a steady demand for medicine in such a way that Galenic principles or botanic knowledge have come down to our day through ‘popular’ or ‘folk’ medicine.⁶²

Loss of technical skills

The uneven transmission of knowledge at a theoretical level can be paralleled to a similar situation in the continuity of technical skills.

Figure 3: Marble pilaster of the baptistery of the suburban basilica of Casa Herrera. Photograph © J. Martínez & P. González



By the 6th and 7th centuries, the various Germanic successor kingdoms were going through processes of state formation, which prompted a new wave of monumental construction linked to a new architecture of power, visible in the archaeological record, particularly in Spain. This was not just as a result of royal intervention (walls, palaces and other administrative centres), but also intervention by ecclesiastical urban elites – especially through episcopal complexes.⁶³ However, by this stage the only main construction projects had been new basilical churches and fortifications, and the skills and even tools for more complex buildings had been lost.⁶⁴ Lost tools include, for example, the *chorobates* (an instrument with which to create isometric lines for levelling), quarry compasses, and set squares used to cut stone. This resulted in a post-Roman architecture of power (civil and ecclesiastical) mostly characterised by simple designs, reused materials and uncomplicated layouts, where new stone was hardly quarried, and reused stones were not reworked to fit their new purpose but simply put together.

The Casa Herrera pilaster (fig. 3) is a 6th-century failed attempt at making a round column out of a (reused) prismatic block of marble without adequate tools, as can be seen from the way in which the prismatic corners were ground rather than having it properly cut to measure in the quarry.⁶⁵ Arguably, another example is the ‘palace’ building at Reccopolis, whose walls are made exceedingly wide for a two-floored building, possibly indicating that the builders did not know how to adjust the width of the wall to the load of the upper

⁶¹ Mannoni 2008: esp. p. xli.

⁶² Jashemski 1999. Hippocratic practices such as vaginal douches have also been preserved: Blythe et al. 2003: 95-100.

⁶³ Martínez et al. i.p., ch. 5.

⁶⁴ Caballero and Utrero 2008; Utrero and Sastre 2012.

⁶⁵ From the final state of the pilaster it can be guessed that the person behind that idea gave up at one point and left the rest of his column rectangular, capital and all.

structure, and preferred to overcompensate rather than to risk a collapse. A last example would be the failed repair of the aqueduct of Los Milagros (fig. 4), also in Mérida, when in the 6th century a pillar was set up to bridge a gap in a collapsed section of the aqueduct, although there is no evidence (direct or indirect) to suggest that the repair was successful or that the arches were finished.⁶⁶



Figure 4: The Visigothic pillar of the aqueduct of Los Milagros (Mérida) was an unfinished attempt to put one of the old Roman aqueducts back into use by bridging a broken gap in the conduit. The pillar itself is not fully vertical or symmetric, there is no evidence to suggest that the conduit was repaired or even that arches were ever put in place. Photograph © Javier Martínez and Patricia González.

⁶⁶ Martínez 2014: 178.

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The widespread use of secondary building material can both explain and be understood by the closure of the quarries, so that the increase in the use of reused material makes quarries redundant, while closing quarries prompts the need to increase the use of reused stone. This secondary use of building material can explain the decline and end of arching and vaulting techniques, because without purposely-quarried voussoirs or centring frames,⁶⁷ it is extremely difficult to build either an arch or a vault. The chronological gap between the 4th century, when these techniques were still widespread, and the late 6th, when there is an increase in the demand, has to be seen as long enough to allow a total breakdown of the apprenticeship transmission chains. The examples of the aqueducts have already been put forward earlier, but more can be added to the list. Even if builders preserved the knowledge of certain aspects of Roman construction, such as the making of *opus signinum* by adding broken pottery or tiles to the lime mortar, post Roman examples are crude and of a clearly inferior quality.⁶⁸ In fact, when new vaulted and arched constructions appear in the West again, they have to be linked to the re-introduction of such techniques and tools most probably through the Umayyads of al-Andalus (late 8th, if not already in the 9th century).



Figure 5: Church of San Juan de Baños, traditionally considered by art historians as Visigothic, there is nothing in its structure, construction technique, or general archaeological comparanda to date it before the late 8th century. Photograph by Isaac Sastre, with permission.

⁶⁷ Ulrich 2007: 172-4. Although it would be difficult to see carpentry losing its trained skills tradition.

⁶⁸ Generically across the Mediterranean late antique *opus signinum* is of a worse quality than that of the imperial period, especially because the pottery or the tiles were not thoroughly or properly crushed, and because of the end of the trade of pozzolanic sands (Lamprecht 1987; cf. Porath 2002).

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The archaeological evaluation of Iberian churches traditionally considered as 'Visigothic' by art historians (such as San Pedro de la Nave, San Juan de Baños, or Santa Lucía del Trampal: fig. 5) shows how the construction techniques must relate to these later phases, rather than aprioristically being assigned to the Visigothic period and an assumed continuation of building techniques not seen in any other contemporary construction. In fact, it is not only the construction techniques which are different (newly quarried or re-worked stone, arches, vaults), but also the layout (not traditional apsed basilicas) and the liturgical disposition of the space (multiple altars) which set these churches away from archaeologically-dated Visigothic examples.⁶⁹

In medicine, it seems that only some of the most sophisticated techniques were lost. Certain types of dental surgery, such as gold-thread sewing, went out of practice due to the narrow and specialised demand for this intervention.⁷⁰ Another example are embryotomies, which clashed with ecclesiastical moral discourses (e.g. Tertullian, *De anima* XXV.5). But generally, basic technical surgery was preserved, even if the more specific tools (such as cranioclasts, curved scalpels, or vaginal specula) appear to have been largely lost. It is very possible that in many cases the collaboration or interaction between medics, midwives, veterinaries, and barbers (and private, family, knowledge) contributed altogether to the preservation of a high general standard of medical knowledge.⁷¹ This widespread distribution of medical lore could thrive, at least in part, on individual initiative and was not wholly dependent on sponsorship or even formal training. Importantly for the survival and evolution of ancient medical knowledge, it was largely independent from state intervention, something which affected engineering more directly.

Conclusions

While engineering and medicine both achieved an extraordinarily high level of development in the Roman period, and were of great use for both the state and society as a whole, the different interaction of these two branches of knowledge with the Roman power led to diverging paths once the Empire fell. The chains of knowledge transmission were much closer to the army and imperial projects in the case of technical construction than was the case for medicine, which reached deeper into society and had many applications. Partly because of this, engineering and complex building practice seem to have been preserved in the East better than in the West, where vaulting techniques and newly quarried stone only appeared again later in the Middle Ages. Similarly, the role of the Church has been misinterpreted or otherwise ignored in the preservation of certain sets of knowledge.

The preconceptions of the Church as limiting or actively opposed to medicine are not borne out by the evidence; nevertheless this misperception has created a collective imaginary which has permeated current research. Examples such as Paul of Mérida, who refused to exercise medicine because he had taken vows to be exclusively a priest and not as a result of a rejection of his previous job, or some radical expressions of early Christianity that used miraculous healing as part of their discourse of power and salvation, have been widely misused and tergiversated in the literature.

⁶⁹ Caballero Zoreda 2000; Caballero and Utrero 2008; Sastre and Utrero 2015; Walker 2016.

⁷⁰ Becker and Turfa: 145.

⁷¹ Cf. Menéndez 2013.

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It is the case that the Church tried to exercise a full control over some aspects of the medical knowledge, such as corporeity and gender. This equally granted the Church an element of prestige and a degree of power over the population by means of its control over institutions devoted to assistance and public health. Engineering and construction, in this aspect, was much more aseptic, less harmful, so the Church was not as interested in controlling or modifying its corpus of knowledge.

It was not only the real need for medical assistance, on the one hand, or buildings, on the other, that marked the continuity or loss of certain sets of skills and professions since the overall survival of human societies happens with or without either of them. Greater determining power lay in certain ideological and cultural factors. Understanding this is fundamental to our grasp the technological and social evolutions of communities in phases of transition or political turmoil, as it was the case for late Antiquity.

Taking aqueducts as a final example, they were not originally built for the sake of their 'inherent' usefulness, but rather as markers of *Romanitas* and, as such, are more likely to be relinquished than other types of buildings or sets of knowledge. When social circumstances change, concrete knowledge (and specific interest) associated to institutions disappears, together with the works, tools, and materials linked to their development. The same happens with Roman *spectacula* which needed a very particular type of political and cultural munificence to build them, maintain them, and keep the games going. The development of traditional Roman monumentality was very limited in terms of available engineering resources and to these political circumstances which did not exist in late Antiquity and beyond. Compared to this, the need for medics can be substituted by family members or other similar professions that would have a prestige much closer to local communities and smaller networks of power, and not just linked to political or economic aristocracies and their projects. This contributed to the preservation of medical knowledge beyond state-sponsored military hospitals, church hospices or technical treatises, resulting in a minimal loss of knowledge and the continuity of the profession.

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Bibliography

Primary sources and abbreviations

AEp = *l'Année Épigraphique*.

CIL = *Corpus Inscriptionum Latinarum*.

Cic. Tusc. = Cicero, *Tusculanae Disputationes*.

CodIust = *Code of Justinian*.

CodTheod = *Code of Theodosius*.

Digest = *Digest of Justinian*.

DLH = Gregory of Tours, *Decem Libri Historiarum*.
 Eph. HE = John of Ephesus, *Historiae Ecclesiasticae*.
 Men. HF = Menander Protector, *Historiae Fragmenta*.
 RegEpist = Gregory the Great, *Registrum Epistolarum*.
 Sidonius Apollinaris, *Epistulae*.
 Suet. Caes. = Suetonius, *Caesar*.
 Pliny, NH = *Naturalis Historia*.
 Pliny, *Epistulae*.
 Teoph., HP = Teophrastus, *Historia Plantarum*.
 Variae = Cassiodorus, *Epistolae Theodoricae Variae*.
 VSPE = *Vitas Sanctorum Patrum Emeritensium*.

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