The technological revolution of the first millennium

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Now that Farrow[1] has again drawn attention to McKeown's[2] conclusion that the great population explosion of the past four centuries was due mainly to improved nutrition it is time to direct attention to Lynn White Jr's analysis of a similar explosion of the sixth to tenth centuries.[3] During that time there was a fourfold growth of population and the transfer of political and economic power from the Mediterranean to the plains of northern Europe. It is impossible to separate the effect of improved nutrition from that of improved technology: population growth without technological growth produces famine, as may be seen today in some underdeveloped countries where self appointed Platonic "guardians" remain convinced that their principles are sacrosanct even when they lead to mass starvation or elsewhere to mass under employment or unemployment.

Exporting swords to Byzantium

In both periods the important technology was that of iron. The iron masters from La Tène had spread along the banks of the Rhine and along the alpine foreland, multiplying pits and bloomeries whose techniques were later exported to Sussex and there persisted into the seventeenth century. They had long made steel by carburation and made piled or laminated sword blades with a sharp cutting edge of steel. By the eighth century they had a thriving export business to Byzantium.

Mediterranean countries have hot, dry summers that speed the decay of humus in the soil. The season for sowing is the autumn to take advantage of the winter rain and the soils are generally light and sandy. The Roman aratrum (plough) was a conical or triangular coulter that parted a furrow but did not turn the soil over, and the disturbance of the soil was so slight that fields had to be ploughed twice—long and crossways—and to minimise turnings of the plough team they tended to be square.

North of the Alps the summer is cooler and rain may fall throughout the year; soils are heavier because water retaining humus decays more slowly. The farmer in the north German plain used a hoe, probably resembling the modern Chillington, which is used in northern Nigeria with its summer monsoon, and he sowed in spring to avoid loss from frost or excessive rain. The aratrum cannot work such heavy soils, and near the end of the sixth century the heavy plough appeared, in principle similar to that of today, with coulter to cut the soil vertically, share to cut the grassroots, and mould board to turn the turf over. Where this complicated tool was invented we do not know, but linguistic evidence suggests that it was known to all the Slav groups well before 564, so that it may have been a Slavic invention or came to them from some Eastern source as yet unknown.

Given the power to haul so complicated and violent a tool through moist, humus rich land, only one passage was needed. On light soils only one yoke of oxen might be needed, but in the heavy, fruitful soil of the valley bottoms up to four yoke were used. To manage a team of eight oxen was difficult—it often needed a boy to lead each yoke—and to turn the team needed a large headland and wasted time and effort. The new plough cried out for fields which were long and relatively narrow, but as on old farmland this would disturb ancient family rights such changes took place mainly in newly assarted land, whether in the valley or on the heights. The only way of dividing the new land between the families who supplied the plough teams was to provide them with strips marked out in the field, so that an open two field system began to appear, one in crop, one fallow.

The earliest European picture of modern harness, c AD 800 (from Lynn White Jr's *Medieval Technology and Social Change*[3]).

Better fed and increased population

The Roman custom of autumn sowing followed the flag at least as far north as Trier, but after 400 there were several decades of poor harvests following increasingly cold and wet seasons so that the north German and Baltic custom of spring sowing spread southwards.[3 4] The crops were different. Barley and wheat from the Mediterranean; peas, beans, and oats from the north. This difference proved to be important because cereals are relatively deficient in some essential aminoacids, while peas, beans, and pulse are generally rather rich in those aminoacids that are lacking in cereals. In addition, these legumes fix nitrogen from the air. One immediate result was a better fed population, which produced more and better babies and probably a surplus of oats.

This surplus of oats was important because oxen are effective but slow draught animals and they produce mechanical power at only about a quarter of the rate that horses can. A team of two horses can plough a field as quickly as four yoke of oxen but only if harnessed properly. The ox harness applied to a horse constricts the venous return and respiration so that its mechanical output is greatly reduced. Many experiments were made; finally the modern rigid horse collar appeared and was first illustrated about 800.[3] Thereafter horses were favoured above oxen for ploughs, harrows, and carts.

The combination of the Roman and the Baltic cropping systems was awkward in a two field system. But with a three field system, properly organised for one field fallow, one spring sown, and one autumn sown there was a much better result—the ploughman got a 50% better return for his labour and this was spread more evenly over the year.

Riding horses used to be a difficult skill. Saddles had been in use for about 400 years, but they were simple, there were no stirrups, and to stay on you depended on the strength of your thighs. If you were really expert you could use a bow. You could use a light lance, held with a bent arm, but any attempt to impale an opponent would pitch you over the tail of your own horse. Somewhere, probably in China, a foot board was attached to the saddle that made riding easier, and the barefooted riders of hot countries used a simple loop into which they could stick their big toe. During the seventh century wooden stirrups appeared, and in 694 the Islamic general al-Muhallab noted that these broke easily and ordered that they be made of iron. This is the first reliable date in the whole sequence.

Foot soldiers versus armed riders with stirrups

Iron stirrups properly secured to saddle made it possible for the horseman to wield a sword without falling off and led to the development of the longsword. The horseman could carry a heavier lance, which soon developed into the mediaeval spear, held firmly so that on its point could be delivered the whole impetus of horse and rider. No footman could stand against the armed rider with stirrups, and by 730 the writing was on the wall for those who still depended on the mass levy of foot soldiers.

But heavy horses, weapons, remounts, and armour were expensive. No one could buy these and at the same time maintain himself in food. Charles Martel and his successors were benefactors to the popes and managed to charge the church lands with the duty of supplying these increasingly heavy cavalry. They did this by relieving the soldier of the task of feeding himself and family by living on the surplus value of several peasant families. So the manorial system was established in which the manor was large enough to provide horse and remounts, horse furniture, spears, swords, and a servant to keep these in proper order, thus enabling the soldier to spend his peaceful days in military exercises. The three field system produced enough oats for his horses. There is some evidence that the children of such soldiers preferred to follow the military occupations, and it has been suggested that one of the crusades was encouraged to rid western Europe of these quarrelsome and troublesome landless knights.

But horse breeding for military horses produced heavy horses unsuitable for war or too many for use as war horses. Mares and geldings were useful for farm work, and by 890 Alfred was expressing surprise that horses were used for ploughing in Norway. So the task of the ploughman was lightened and within a few centuries the outlying homestead was deserted and peasants crowded into the village where they could find blacksmith, priest, fellowship, news, and a greater choice of girls and sons in law.

The last invention seems to have been the iron horseshoe; hoofs are sensitive when wet, and the iron horseshoe saved the hoof on rough soils and difficult journeys. They first appeared about 900 and by 970 were usual for all long journeys.

So by 1000 all the technical skills needed for the application of horse power to human needs were available, the essentials of the feudal economy were in place, and "Man had been a part of nature; now he became her exploiter."

References

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Research and the general practitioner

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"Know then thyself, presume not God to scan,
The proper study of Mankind is Man."
Pope

The Provincial Medical and Surgical Association, the parent body of the present British Medical Association, was founded in 1832. It is significant that the BMA owes its origins not to city practitioners in London but to a group of provincial doctors who believed that the provincial practitioner had as much to offer in the study of disease as his counterpart in the metropolis. The foundation year was only nine years after the death of Edward Jenner, so that the founders had before them the shining example of a unique scientific achievement made by a country practitioner working in the hills and valleys of his native Gloucestershire.

There were during the nineteenth century in England other country practitioners whose discoveries were to make a major contribution to the advance of medical knowledge. William Budd, working as a country doctor in his native village of North Tawton in Devonshire in the 1830s, established that typhoid fever was a communicable disease and that it was due to an infectious agent that could be transmitted by contaminated water from one patient to another.[1] In 1841 he moved to practise in Bristol and became an active member of the fledgling Provincial Medical and Surgical Association. There in 1866, following in the steps of John Snow, he showed how a cholera epidemic in the city could be controlled by hygienic measures. William Budd pointed to the particular advantages enjoyed by the country practitioner in studying the transmission of infectious disease.[2] In his classic work on typhoid, carried out when at North Tawton, he wrote: "Having been born and brought up in the village I was personally acquainted with every inhabitant of it and being, as a medical practitioner, in almost exclusive possession of the field, nearly everyone who fell ill, came immediately under my care. For tracing the part of personal intercourse in the propagation of disease, better outlook could not possibly be had."

MacKenzie and cardiology

Perhaps the most outstanding example of research in general practice during the nineteenth century is provided by the career of Sir James MacKenzie.[3] MacKenzie was born at Pickstonhill Farm in a village near Perth in Scotland in 1853. He did not excel at school, and his mother was told by one of his teachers: "Mrs MacKenzie, your James is the most stupid boy in the school." This was the lad who was to graduate in medicine at the University of Edinburgh in 1878, become a fellow of the Royal Society, and found the science of cardiology in Britain. In 1879, modestly having no