Antonio Saltini

AGRARIAN SCIENCES IN THE WEST

translated by Jeremy J. Scott

VOLUME FOUR

The Advent of Steam Power and Industrial Fertilizers

Nuova Terra Antica

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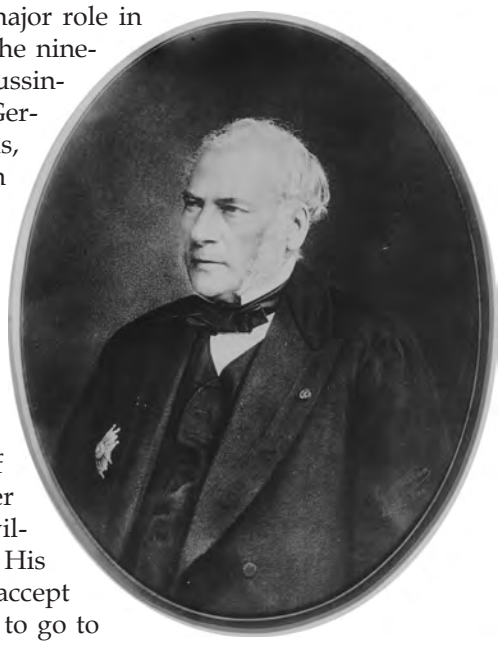
In memory of Bartolo Merrina, a son of the volcanic island of Lipari and a master of the waters around it. In remembrance of a night when, by the light of the moon, he struggled – ultimately in vain – to reel in a swordfish that was longer than our fishing boat. The duel was the same as that which had been fought by generations of islanders, none of whom would easily have admitted defeat when trying to land a fish large enough to feed an entire family for months.

Nuova Terra Antica

III
From the Germination of Seeds to the Exploitation of Crops: the Metamorphoses undergone by Organic Molecules

An Explorer of the Pampas appointed to a Chair at the Paris Conservatoire des Arts et Métiers

In the ranking of those who played a major role in European agronomy around the middle of the nineteenth century, Jean Baptiste Dieudonné Boussingault comes directly after Liebig. Like the German a rather overbearing personality, he was, however, someone who pursued his research in a somewhat purer spirit of scientific discovery (as we have seen, Liebig happily accepted credit for insights which had been first formulated by others but then ignored by the scientific community).



«If I might be allowed a comparison, I would unhesitatingly compare the relations between our young French volunteer and General Bolivar with those between our heroic compatriot Lafayette and Washington. Without presuming to place the services provided by Boussingault on the same level as those provided by Lafayette, I would argue that our country can be proud in seeing how, throughout the world, its most noble sons place themselves at the service of oppressed peoples who feel themselves worthy of liberty.» This is how the scientist and patriot Boussingault was commemorated at the funeral service held on 14 May 1884 within the Conservatoire where he had taught for 42 years; the words were pronounced by Colonel Laussedat, speaking on behalf of the institution. This photograph from the archives of the Académie des Sciences shows Boussingault wearing the cross of the Légion d'Honneur, whilst Laussedat would recall that the Frenchman always said the medal he held most dear was that awarded to him on the battlefield by Simon Bolivar.

Born in Paris in 1802, Boussingault was a precocious, largely self-taught student, who completed his studies at the *École des Mines* at Saint-Etienne in the department of Rhône-Alpes before being appointed manager of a small mine at Bechelbronn (today Merkwiller-Pechelbronn), near Weissenberg (Alsace). His spirit of adventure subsequently led him to accept a proposal from the Colombian government to go to Bogotà and set up a mining school. Once in South America, he got caught up in revolutionary politics and soon abandoned mining in order to fight alongside Simon Bolivar. However, he still found time to venture into some of the continent's most inhospitable regions, pursuing research intended to answer a series of questions that had been proposed to him by Alexander Von Humboldt (a powerful figure in contemporary science who, as we have seen, had launched Liebig on a career of research that would lead to wealth and fame).

Boussingault left South America in 1833, and the following year presented his doctoral thesis of ground temperatures in equatorial regions – a work which earned him the chair of chemistry at Lyons University. He also re-established contact with the owner of the small mine at Bechelbronn, becoming his son-in-law in 1835; the previous year he had formed a business partnership with his future brother-in-law, with the aim of applying

have if used as feed directly. In fact, this was claimed by many farmers, but nowadays everyone admits the opposite is true. The organic principles in the potatoes that are converted into alcohol are clearly lost for nutrition.

This does not mean that the making of domestic sugar or the distillation of tuber roots are less advantageous than the breeding and raising of livestock.

This discussion aims merely to remind people that there is a limit on the amount of organic material that can with real advantage be removed from a farm.»

Judged by its effects upon soil fertility, the advantage of a crop was in direct proportion to the amount of organic material it synthesized from the elements in the atmosphere and restored to the soil, but in inverse proportion to the amount of organic material it drew from that soil. On the contrary, it is argued, those crops would be disadvantageous which drew from the soil most of the organic matter that was ultimately sold as farm produce and thus impoverished the soil reserves available to subsequent crops.

In drawing up a balance sheet of organic substances, Boussingault prepares a series of tables for the main agricultural crops, listing the results of analysis to determine how much carbon, hydrogen, oxygen, nitrogen and resultant ash were present in a kilogram of the dry matter and within the residue, roots and stalks returned to the soil after harvesting (either directly, by being dug back into the land, or indirectly, by serving as feed that resulted in manure). He also analyzes the chemical composition of manure to determine the contribution made by single crops and rotation cycles. Analysis of the results meant that, from the average quantity of individual harvests, he could determine the amount of each chemical element in the produce and residue from every crop. The sum of the quantities of each element in the harvest, in the crop residue and in the manure used by the rotation cycles meant that he could establish a chemical balance sheet for a series of crop sequences. Applying the criterion he had already outlined, he could then assess the net balance between the organic substance produced, that removed in the form

After the prestigious undertaking of publishing the *Maison rustique du XIXe siècle*, the same publishing house – Le Bureau de la Maison Rustique – would begin to produce a monthly *Journal d'agriculture pratique, de jardinage, et economie domestique*, with contributions from the same authors. The first editor of the periodical was Alexandre Bixo, who had coordinated work on the first volume of the *Maison*; he would be succeeded by J. A. Barral (in 1850), who in turn would be followed by Edouard Lecouteux (in 1866), both "pupils" of De Gasparin. At the beginning, the publication was noteworthy for the quality and precision of its engravings and the number of its lithochrome plates; however, the financial burden imposed by these illustrations would lead to them being abolished. This image from the first volume of instalments for the year 1865 is a lively depiction of sheep-dipping on a farm owned by Prince Jérôme Napoléon, with the six labourers using equipment developed by Bigg: a basin, special baskets and a winch to lower the sheep in and out.

AGRICULTURAL PICTURES.—THRASHING.—DRAWN BY DUNCAN.

Carefully coloured, this engraving by Linton to a design by Duncan shows a cereal crop being flailed. It was published in the *Illustrated London News* on 28 November 1846 – that is, at a time when mechanical threshers were already widespread. Nevertheless, as the image suggests, more primitive methods continued to survive in remote areas. The bare tree beyond the doorway indicates that, as laid down by tradition, the crop is being threshed in winter time.

with Lawes' buyers having to scout the slaughterhouses of both Britain and the continent; as we have seen, Liebig would even claim that those suppliers stripped the ossuaries of Napoleonic battlefields to fed the maw of Lawes' factories. However, the fortunate businessman did not derive the largest part of his income from selling the essential product of his process. The bulk of his money came from licence agreements which allowed his competitors to use his patents to produce phosphoric acid on an industrial scale from the reaction between sulphuric acid and mineral phosphates – and it was these massive quantities that were the key to the development of a fertilizer industry. When Lawes had patented his process, phosphorites were practically unknown; now their availability meant his process was the linchpin of an industry in constant expansion. And for each ton of superphosphate they produced, the manufacturers paid Lawes a licence fee of 10 shillings.

A wealthy magnate at less than thirty years of age, Lawes decided to invest part of his fortune in a large-scale project of agronomical experimentation. The decision reflects that interaction between the worlds of science, economics and politics which was then a feature of British society – the same interaction that had inspired the founders of the Royal Society and the Royal Institution and then led to the creation of bodies which combined scientific research and education. Following in the footsteps of Rumford and Joseph Banks, John Bennet Lawes became yet another of those daring – perhaps ruthless – bankers and entrepreneurs who developed into philanthropists and patrons of the arts and sciences. Thanks to his mercantile know-how and the resources it provided, Rothamsted came into being; and thanks to the clear-sighted plan of experimentation he envisaged, it would become the body that brought to fruition an approach to agronomy that had first been brought to England from the Low Countries by Weston and then

That December response – with the curt title Reply to Baron Liebig's *Principles of Agricultural Chemistry* – sees Lawes overcome his rather gentlemanly shock at the unexpected tone of his opponent and pass onto the attack. And the attack is all the more serious for being published in the *Journal* of the Royal Agricultural Society, the authoritative 'mouthpiece' of those self-same scientific circles which, in 1840, had commissioned Liebig to draw up a report that would then play a major part in establishing his international reputation.

In opening its pages to Lawes, who was there free to express himself without any of the constraints imposed by academic hierarchy, the *Journal* made it clear that the British agronomical community was siding with the industrialist-scientist, whose work thus became a symbol of the nation's agronomical research. At the same time it was clear that the scientific community as a whole frowned upon the German's pig-headedness in refusing to take seriously a plan of research which had generated data that clearly merited careful discussion and assessment. Indeed, proof of the attention being attracted by Rothamsted can be seen in the same issue of the *Journal* as published Lawes' response: Philip Pusey's mention of the fact that the experimental station had recently been visited by Jean Baptiste Dumas, the doyen of French chemists and a personal friend of Liebig's, who at the end of his tour is said to have expressed praise for the experimental rigour of the work being done there.

The *Reply* itself is a wide-ranging essay that contains not only an analysis of the results of the on-going experiments – whose progress had generated yet more evidence supporting the theses put forward in Lawes' previous report – but also an ample survey of related texts which provide for a more detailed comparative framework.

One can break down the article into four parts, the first being an analysis of Liebig's theory. Highlighting the incongruences and changes of mind that can be seen in the various editions of the German's *Organische Chemie* and *Chemische Briefe*, this aims to scotch Liebig's claim that the previous note by the Rothamsted experimenters showed they had not really understood his work.

The second part of the article brings together numerous quotes and comments from Liebig's work that appear in studies by agronomists in England, France, Germany and the United States, all of which confirm that the interpretation which Lawes and Gilbert had given of the "*Mineral Theory*" was perfectly in line with the way it was understood by the international scientific community.

Beswick figurines of a Jersey cow and bull. Developed on the islands that are the most southerly part of the British archipelago, these might be considered the first masterpiece of British selective livestock breeding, given that its unique combination of characteristics was obtained on an island that ruled out the maintenance of large herds (generally essential for selective breeding). Small in size, the cow does not strip pasture bare because it can also graze on land exposed at low tide. In relation to body weight, it is one of the most prolific dairy cows on the planet; furthermore, its milk has such cream content that the Jersey could – through cross-breeding – be used to increase the butter yield from some of the world's best breeds of dairy cattle (for exemple in New Zealand).

sive positions occupied by the straight line whose ideal progress along the pre-chosen curve had generated the surface of the mouldboard (the so-called "generating line").

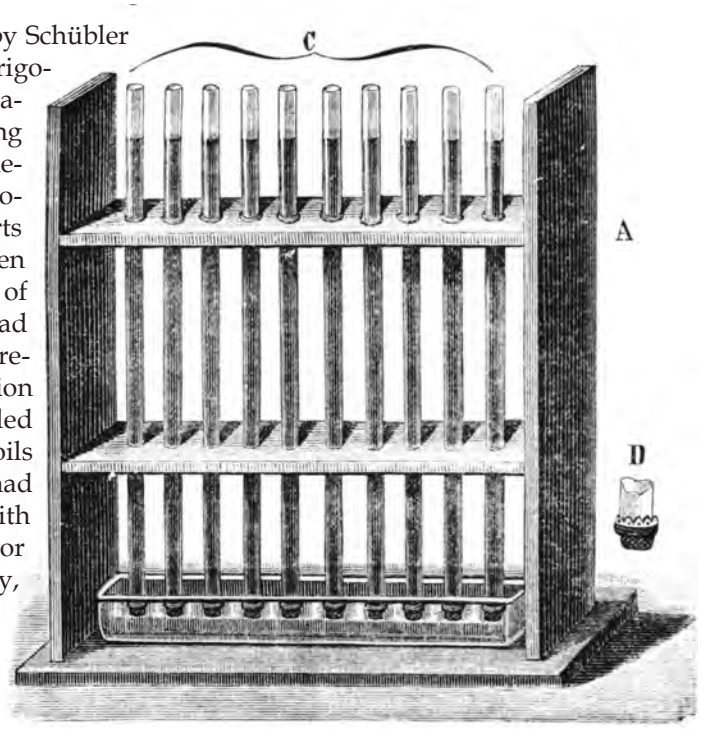
Plectoidal Surfaces and the Application of an Inclined Plane

Having established these premises, Ridolfi proceeds to a detailed mechanical and geometrical discussion of the goal he had set himself: identification of the curve which would turn the cut strip of earth with a homogenous effort exerted on each of the infinitesimal components into which one can divide any surface. For a plectoidal surface, this division involves tracing a series of latitudinal straight lines that define an equal number of skewed polygons (skewed because they have one curved side). Given that the motion of each of the points on each of the straight lines is independent of all the others, the motion of the point moving from the edge of the mouldboard across its entire surface follows a curved line which, Ridolfi postulates, may, in terms of infinitesimal calculus, may be considered as rectilinear, and hence can be analysed as if it were motion across an inclined plane. On the basis of this, the question to be resolved can be posed in these terms: which of the various plectoidal surfaces makes it possible for a force applied parallel to the base of that plane to put each of the infinitesimal components in a state which Ridolfi defines as "the verge of motion" (the point at which static inertia is overcome). If

TRIAL OF LORD DUNMORE'S NEW STEAM PLOUGH.

This implement, designed to be drawn behind a traction engine, is a double-share reversible plough, whose direction could be changed with relative ease after the completion of each passage over a field. The image reveals that the light weight of the plough was in keeping with the limited draught power supplied by such traction engines; cable-drawn reversible ploughs – powered by powerful fixed steam engines – could be much heavier and more sizeable.

It is, De Gasparin observes, the method proposed by Schübler which provides a measurement of such tenacity as a rigorously scientific mechanical property. This involved kneading a soil sample into a paste with water and then putting it in a prismatic mould on top of which is placed a one-kilogram weight. Once the soil has dried out, it is removed from the mould and then placed upon two supports that are 4 centimetres parts; at the exact mid-point between those two supports, a wire is passed around the block of soil and to its end is attached a container, into which lead shot is placed until the weight causes the sample to break. The relation between the weight and the cross-section of the sample (identified as a standard 225 mm^2) provided a comparable measure of the tenacity of the different soils tested. De Gasparin, in fact, gives the figures Schübler had obtained by applying the test to his own series of soils, with values going from 0.00 kg for siliceous sand to 18.22 kg for pure clay. However, even when carried out meticulously, the procedure can give different values for the same soil, as De Gasparin points out: there simply have to be a few grains of sand in the sample used for the cohesion to vary. From the analysis of a series of tests, he identifies the range of these variations, ranging from a minimum of 75% for the soils of Tarascon to a maximum 94% for the soil from Hoffwyl.



The simple appartus for measuring soil water-retention capacity designed by Fausto Sestini, author of the first Italian textbook on soil science. Ten 75-cm glass tubes open at both ends are filled with soil and then weighed (the samples being held in place by cotton wool). Water is poured into one end and after it has ceased dripping from the base one re-weighs each tube, the change in weight for each giving the water-retention capacity. Pouring water into the sodden soil samples will also enable one to determine the permeability of each sample via the time it takes for water to begin dripping again from the base.

In the second section of the fourth part of the volume, De Gasparin makes a significant addition to his explanation of soil tenacity, after illustrating the procedure of levigation. He points out that the level of tenacity is directly linked to the amount of material obtained in the second and third sedimentations – that is, those which require longer periods of time. Hence, the greater the percentage of fine particles, the greater the tenacity of the soil. De Gasparin wonders if it is possible to establish a mathematical correlation between the two readings. According to the Frenchman, microscope examination of the third sedimentation explains these differences, revealing that the samples with higher levels of tenacity contain whole micelles of clay, but those with lower levels contain higher amounts of quartz crystal, calcareous fragments and clay particles modified by combustion (in the Camargue, for example, it was common practice to denshire fields).

«If the tenacity of soils is very important in establishing how much labour is need to work dry terrain, the plasticity of soils – that is, the readiness with which they adhere to farming implements when they are moist - is no less important.» This clear statement introduces De Gasparin's illustration of how to measure another property that is fundamental in defining the physiognomy of soil: its adhesiveness. The procedure which he then describes in the next chapter for measuring this property follows the highly logical method devised by Schübler. The soil sample, he says, should be mixed with clear water until it can absorb no more then spread within a mould, its surface being made perfectly smooth. On that surface one then places a disk of beech wood (10 cm2) which will, of course, adhere to the wet soil. A hook on the upper side of that disk can then be attached to one arm of a balance; to the other arm is attached a tray, to which lead shot is added until its weight causes the disk to separate from the soil. That weight is the measurement of the force of cohesion between the damp soil and the surface.

The values Schübler has obtained for a range of soils varied from 1,32 kg for pure clay to 0.19 for siliceous sand. The clear parallel between the values obtained for tenacity and adhesiveness reveal the fact that the two properties had the same physical origin. In fact, both depend upon the force of attraction between the soil particles, which is in inverse proportion to their size.

In his classification of man's developing exploitation of natural resources, De Gasparin includes a stage in which there was simple gathering of wild-growing food – what modern archaeology recognises as the initial phase in the process whereby human groups learned to survive. "Reed Bundlers in the Maccarese area", painted in the final decades of the nineteenth century by Ettore Roesler Franz, shows this practice would long continue. Those looking for reeds and sticks at the edge of the marsh also keep their eyes open for fish, frogs and mushrooms that could be a source of food.

traditions in the concession of the former would have to be abandoned. The conversion into pasture required new forms of tenancy agreements, which – the Frenchman observes – could only be introduced "if agricultural were separated from political issues": the allusion is to the on-going battle in Ireland between smallholding tenants (tenaciously attached to the land from which, with enormous difficult, they obtained enough for their sustenance) and landowners who were eager to transform their property into pasture for the livestock that might supply the ever-growing demand for mutton and beef in an increasingly industrialised England.

Inspired by his own aversion to the peasant classes, De Gasparin's comments would be borne out by future events. After having shown a total lack of foresight with regard to developments in land exploitation in his own region, the Frenchman would be more fortunate with regard to Irish pastureland, even if this "fortune" was largely due to a factor he could not possible have predicted: the arrival of the downy mildew that would decimate potato crops and cause a famine that wiped out entire peasant families and resulted in emigration en masse. It was this which would enable landowners to convert recovered arable land into pasture, with the production of fodder becoming the most profitable form of land exploitation in Ireland; from the middle of the nineteenth century onwards, the country became one massive expanse of grass for the dairy and beef cattle whose products supplied an apparently insatiable English market. However, setting aside the acumen of De Gasparin's comments on the advantages of pasture land over arable crops in a country peculiarly suited to the production of fodder, the discussion here is actually unrelated to what is supposed to be the topic of this section: the nature of the pastoral economy. Ironically, though he himself was a native of a region with ancient pastoral traditions, the Frenchman dedicates no real attention to such economies in his examination of different agricultural systems.

In the following pages, De Gasparin does, however, make one or two significant observations with regard to a matter which had already exercised some eighteenthcentury naturalists and continues to be a key topic of interest in ecological studies of the twenty-first century: the dangers of erosion on hill and mountain slopes due to the deforestation carried out in order to create pastureland. In De Gasparin's day, concern was particular high in the southern Alps, a place of summer pasture for the huge herds that spent the winter in the Camargue and Crau areas. Defending a practice which he believes to make an essential contribution to the economy of his own regions, the Frenchman here draws what he claims is a key distinction between private pastures rented for the

De Dombasle's five-share scuffler. With some variations, the model reproduces the English design typical of the days of Young, for by 1836 the French agronomist had already admitted that his own design was out-of-date. By the time a Pisan craftsman created this model (in 1880) British ironworks were flooding Europe with iron or steel scufflers and cultivators. Indeed, rather than being a teaching aid for future agronomists studying agricultural engineering, this model will already have been a historical curiosity. From the end of the shafts to the end of the beam, it measures 54 cm; at its widest point it is 28cm and the shares are 8.5 cm long and 6 cm wide.

The scientific thoroughness of his experimental approach – and the practical success of his proposed sequence – are legitimate sources of pride for Ridolfi, whose research thus opens a first breach in a wall of tradition that had prevented development and progress within the agriculture of his region. Yet if the growing adoption of this new rotation sequence was his first great triumph, it would also be his last. As we have seen, by the time he held these lessons in Empoli the Pisa School of Agronomy had been closed down, and the young scholar (Cuppari) to whom he had entrusted his university teaching when he committed himself to political activity had by then become the mere tenant of the Porta Piagge farm, abandoning university teaching in favour of private lessons. The decree re-opening the institution would be signed by Ridolfi himself in 1859 as minister of the plebiscite government, but the premature death of his successor just ten years later would further obstruct the development of original methods adapted to Italian agriculture. Though increasingly absorbed by his parliamentary work, Ridolfi would maintain a passionate interest in research to the end of his life; however, this interest was not enough to halt the inevitable decline in the hill-farming of Central Italy which he himself had foreseen.

The Absence of a Clear Division between Crops: an illusion of agricultural prosperity

One part of Ridolfi's attempt to develop an agronomy that would result in hill-farm yields being both higher and less aleatory is his criticism (formulated in the twelfth lesson) of what to British, French or German eyes constituted one of the most beautiful features of the Tuscan landscape: the commixture of herbaceous and arboreal crops. The interwoven lines of olives and vines that extended between stretches of sown crops may have been an enchanting sight for Goethe or Montaigne, but all the agronomist saw was the constraints that arboreal and arable crops placed upon each other – constraints which resulted in none being able to achieve its full potential, to produce the sort of yields it might have done if not grown in combinations with others. Furthermore, such distribution of trees and crops made farming more labour-intensive and thus increased the costs a farm had to meet.

In discussing the difficulties faced when trying to introduce modern rotation sequences into Tuscany, Ridolfi says:

Ridolfi stresses that the number of villages and towns dotted around the Tuscan countryside provide a ready market for the produce from copses, which was used as fuel or in numerous manufacturing activities. This picture, taken at Radicondoli near Siena in 1981, shows how little things had changed since his day: lines of carts and mules had transported the wood that was still important to the economy of these Colline Metallifere, so called for the rich mines which were one of the foundations of Siena economic splendour.

discuss the methods for growing apples and pear trees in "pyramid " form, or training peach and plums trees to growing in "fan" form. Both of these forms were characteristic of fruit farming in France, and – taking his lead from the Roda brothers, whose works he recommends to his audience – the Tuscan holds up the French model as the one that should be followed in Italy if this agricultural sector was to make a positive contribution to the rural economy.

From the fruit trees to be found growing in rows or individual clumps within the gardens of plain-land areas and lower inclines, Ridolfi now turns his attention to those that were typical of higher hill slopes, offering a very effective account of the patient work of generations that had resulted in the uplands of Tuscany being covered with woods of chestnut trees (the source of an important supplement to the diet of those living in mountain areas – so much so that Giovanni Cherubini would identify a "chestnut civilisation" as one component of the mosaic that made up the history of the region). In the mid-nineteenth century many of those chestnut woods were still a remarkable source of fruit, despite being neglected by landowners who did not even bother to replace fallen trees (essential if the productivity of the plantation was to be maintained). And having vehemently denounced this neglect, Ridolfi is equally fervent in urging his audience to take greater care of the region's woodlands as a whole; after all, they were an essential feature of the layout of the Tuscan countryside, where a sizeable part of farms might be given over to a stretch of scrubland or an oak wood. Rather than being managed as a precious resource, these Tuscan woods were, Ridolfi argues, simply looted – for firewood, fresh foliage for livestock fodder, dry leaves for animal litter – without any thought being given to the great yield that might be obtained from them if care was taken to maintain a constant cycle of regeneration. One way of exploiting woodlands which he describes as particularly harmful was the habit of removing the dead leaves with which the ground

«Before drawing up plans for the drainage of terrain one should possess exact knowledge of the quality and state of the ground itself, and to this end one should adopt the following procedures:

1. Use probes and sink wells to determine the condition the ground is in;

2. Use a water level to gauge the whole terrain that one wishes to drain, and the individual parts thereof, and to determine their elevation;

3. First on a map, then using posts set into the ground itself, trace out the general and detailed layout , to set if it meets what is required of it.

Having established the qualities of the terrain, one will be able to decide if it is worth draining. You will also identify the good and bad points of the terrain and what causes it to be waterlogged – that is, if the water runs onto it from above or rises from below; if it is soaked with stagnant water or that from underground springs. And all of these observations will enable you to deduce guidelines for ways of improving the land.

The use of probes and the water level will enable you to establish at what depth you should place the running courses and what incline one should give each of them. They will also *allow one to determine the consistency of the soils and enable you to analyse them. And the wells you sink will make it possible to calculate the amount of water there is in the ground, to see to what depth it is found, and thence be able to draw off that water for irrigation of lower-lying land.*

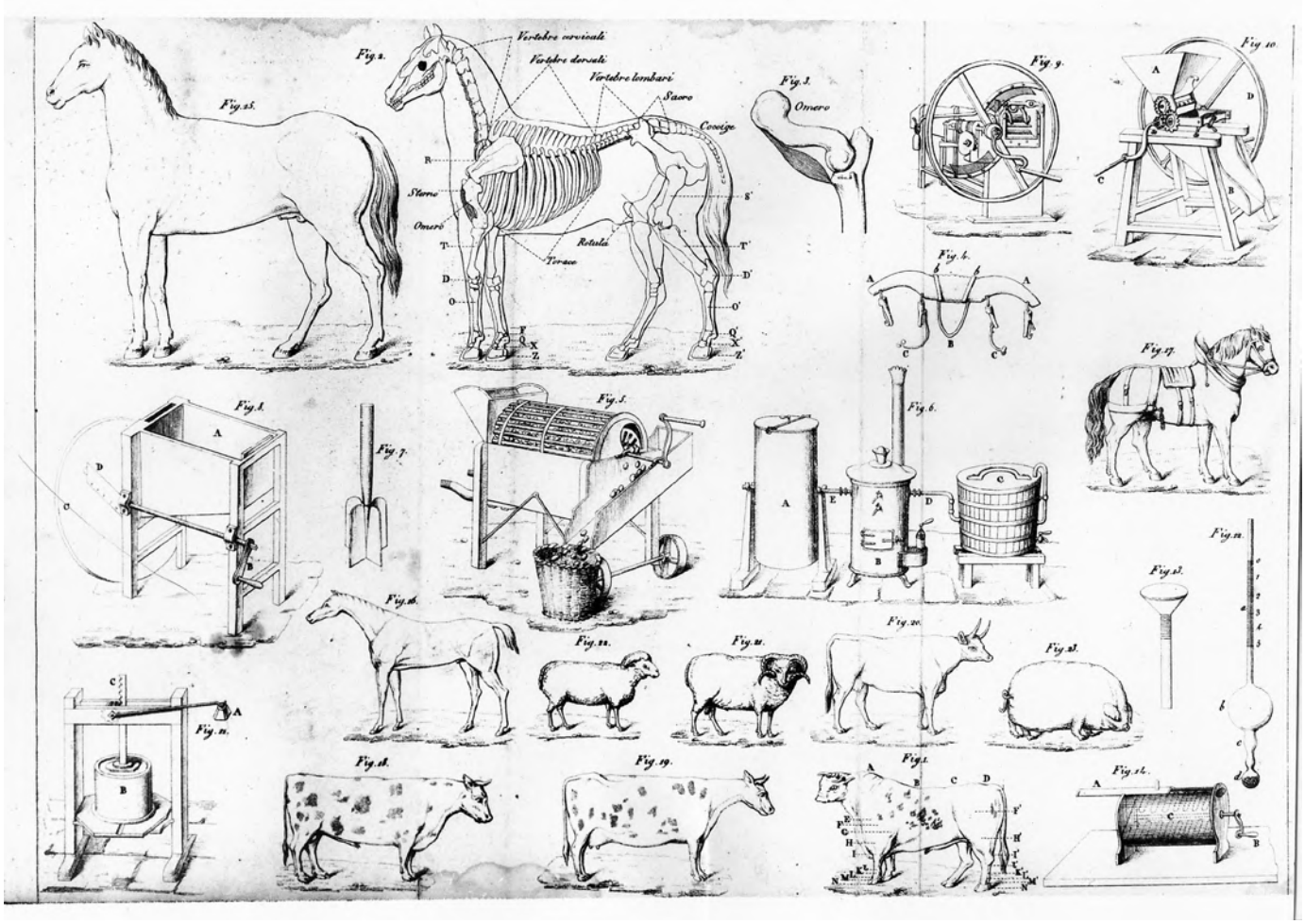
By carrying out the abovementioned studies one can determine the number of drainage and collection ditches that must be created, as well as their length and cross-section. One can thence establish how much they will cost, in terms of labour, expense on tools and equipment and transport of excavated material, as well as factoring in the cost for damage to the drainage system. (routine maintenance) Finally, one will get some idea of the number of underground springs there are and the quantity of water they produce, thence of the costs relating to them [...] After having made all these calculations one also has to compute the increased value that the land will acquire once it has been reclaimed, together with the produce and other profits it might yield. This should be done by comparing them with other land that is in good condition and yet similar to the land to be reclaimed in terms of quality and position. One should also take into account the produce resulting from the waters collected by the drainage ditches – that is, consider whether that water might be useful for irrigating other lower land, and over how many hectares [...] And then, once one has calculated all the costs and all the profits associated with a drainage system, and compared all expenses with the resultant produce, you can make a fully-informed decision as to whether it is worth undertaking the work [...]»

Given the demand for human and animal figures for cribs in both patrician homes and churches, the manufacture of painted terracotta figures in Naples was a veritable business, attracting artists of such standing that their work would gain international recognition. In a less opulent style, the terracotta work produced in Caltagirone (Sicily) made this city another centre for a centuries-old Mediterranean craft, even if one can clearly distinguish between the spirit and tastes that inspired the figures produced in the two places. In the nineteenth century, one of the greatest craftsmen working in the Sicilian tradition was Bongiovanni Vaccaro, who produced this scene of a poor peasant supper: a woman dressed in rags serves up soup to three men in equally shabby garments seated at a table of rough wood.

The Study of Anatomy and its application in Animal Diagnostics

Their title echoing that of a work by Boussingault, the three volumes of the *Economia Rurale* are based on a course of lessons for university students; rather than being concerned with the results of original research, they are designed for the teaching of consolidated notions regarding crop cultivation and livestock farming. Despite their modest aim, however, the third volume– dedicated to *Pastoral Farming* – contains some of the most interesting pages in Cuppari's entire work: in setting before his students the knowledge of anatomy and physiology that they will need for the rational exploitation of livestock, the Sicilian makes such insightful use of what he had learnt in his medical studies that this survey of applied zoology ranks as the very first work in Italian to deal with the subject of animal diagnostics – that is, the study of the correlation between an animal's morphology and the characteristics that make it suitable for a specific form of economic exploitation.

We have already seen how, throughout history, various writers on matters agronomical had studied the morphology of animals, believing it to provide sure evidence as to their productive capabilities. Such interest can be traced back as far as Columella, whose attempts to define ideal types of specific animals would, in the eighteenth century, still be recognised by many as providing unparalleled parameters for assessing livestock. Then would come English authors, aiming to draw up a full account of the criteria that had been used by the nation's livestock farmers in what had been the first period of rationally based selective breeding. However, the indifference to theoretical constructs that was apparently an innate part of British intellectual culture meant that it would take long decades for the experience acquired on farms, in livestock shows and at animal auctions



From what was clearly an economic edition of the work, a plate that combines all the images which (in the third volume of Cuppari's *Lezioni*) served to illustrate the morphology and skeletal structure of the most important farm animals. Given its "nobility", the horse is the animal which appears first in the discussion.

a lack of gradient, our plain areas are much better for crop cultivation, especially where there is irrigation water drawn from the mountains.

As for climate, we have the widest range – from the coastal shores of Sicily to the harsh and snow-covered ridges of the Alps and Apennines [...]

These afore-mentioned characteristics mean that, overall, Italian agriculture should look to the following in order to develop: 1. The cultivation of arboreal plant species, especially in its southern regions and on its hill slopes; 2. the cultivation of artificially-modelled terrain, taking great care to improve the layout of terracing and the drainage of water; 3. Skill in carefully and economically draining away the excess water to be found in plain-land areas; 4. Finding new sources of irrigation water and the best possible methods for exploiting it; 5. Improvement in methods of working soil, which in Italian agriculture has to make up in good measure for the [low] quantity of fertilizers; 6. Given that the country is not very suitable for an increase in fodder crops – thence of livestock and the manure it produces – it must look for progress in finding other forms of fertilizers, whilst also being very careful to collect every scrap of solid fertilizer and every drop of liquid manure.»

The outline reveals Cuppari's knowledge of all the areas of the country, together with his ability to compare the conditions and produce of each with those in the different

This 1882 by Fattori depicts a market of *Maremmani* cattle held at San Godenzo; a scrubland area with a few oak and cork trees, this was on the low uplands raised above the marshland plain, so was a place where malaria did not pose too great a threat. The colour of the foliage suggest this is springtime, lending support to the idea that the market for draught animals was held in the weeks when peasants throughout Tuscany needed to replenish their stocks of oxen prior to backbreaking ploughing of fallow land during the summer months. Whilst *Maremmani* oxen might be bought for other areas in the region, they certainly had no competitors as draught animals during the hot summer in the Maremma itself. Some did attempt to replace them with the Chianina oxen that were the pride of the Siena and Arezzo; however, they ended up having to unhitch those substitutes after just half a day's work, the massive beasts already on the point of collapse.

countries that were the nation's competitors. He clearly sees that Italy could not defeat such competitors by focusing upon livestock production (for which the conditions in other European countries were much more favourable); instead, it should make the best possible use of the resources available to a hilly Mediterranean country suited to the cultivation of arboreal species which encountered insuperable difficulties in more northerly climes. The argument was a solid one in Cuppari's own day. However, reading his text more than a century later, one can see that he underestimated the potential of the nation's water-logged plains. In the mid-nineteenth century, when he was writing, only the first timid steps had been taken towards the massive steam-powered drainage projects, which, in the space of fifty years, would create vast irrigated plains that were perfectly suited to fodder crops and animal-feed cereals and thus became the location of intense new livestock farming.

Yet having said this, Cuppari's analysis remains perfectly valid for the entire hill-land areas of Central and Southern Italy, combining exact geographical description with a recognition of the advantages to be obtained from a focus upon the particular characteristics of typical local produce. In the nineteen century, in fact, Italy was the prime producer of a range of foodstuffs that were then considered luxury items - wines, olive oil,

Abstract