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Presidential Address

The Theory of Metals in the Works of the 13th-Century Encyclopaedists

Delivered by DR. F. SHERWOOD TAYLOR on *5th May*, 1952

It is a part of the function of the historian of science to assess the value of the scientific theories of former time—to consider the satisfaction that they gave to their holders. The historian of chemistry is confronted with one great theory which flourished for more than two thousand years, namely, the four-element theory of matter, and he finds that a considerable body of facts, physical, chemical, biological, and astronomical was understood in these terms.

The men of the thirteenth century did not expect of a theory all that we expect. The modern man of science expects a new theory to lead to the discovery of new laws and new phenomena, and, generally, to the making of quantitative predictions about the natural world. Only secondarily does he enjoy in it the spectacle of phenomena being fitted into the system of science and thereby explained: rarely does he expect his theories to contribute to the general view-point of Man with regard to Nature. In the thirteenth century, however, the importance of these objects was reversed. The prime satisfaction was in the fitting of natural phenomena into the general philosophical scheme of the universe, second came the intellectual pleasure of an explanation and only in rare instances did the theories of the time allow of qualitative, far less quantitative, predictions being made.

When the four-element theory became known to the Western World in the twelfth and thirteenth centuries, it seemed to throw a flood of light on hitherto inexplicable phenomena. Some of these explanations seem today to be very absurd, many being explanations of incorrect observations or mere fables, often in terms of principles no less untrue. It occurred to me some years ago that it would be interesting to consider the explanations given to the existence and properties of a class of bodies which was well-marked, interesting and the subject of much practical study, namely the metals, and to confine this study to the period when the four-element theory was well understood and much esteemed, namely the thirteenth century. Such a study might be a means of assessing what the four-element theory could do for chemistry.

The sources of our knowledge of the XIIIth-century theory of metals are to be found

(*a*) in the scientific writings of various encyclopaedists, or writers on scientific subjects,

(*b*) in alchemical texts.

The former is a very much richer source, for the alchemical texts dating from this period do not in general discuss the nature of the metals in any detail, nor do their views on this question appear to differ from those of the encyclopaedists.

Discussions of the nature of metals are found in the writings of

(1) Robert Grosseteste (*De Liberalibus Artibus*).
(2) The *Summa Philosophiae*, attributed to Grosseteste but actually deriving both from him and from Albertus Magnus.
(3) Roger Bacon (*Opus minus*).
(4) Vincent of Beauvais (*Speculum Naturale*, *Speculum Doctrinale*).
(5) Albertus Magnus, especially in his *De Mineralibus*.

The last-named gives very much the fullest and clearest account of the matter. Vincent of Beauvais is interesting chiefly as indicating contemporary sources, but as his writings on metals are a mosaic of quotations, he hardly presents a point of view: his interest is chiefly focused on matters of fact and he gives little attention to theoretical discussions. The other XIIIth-century encyclopaedists, William of Auvergne, Thomas of Chantimpré, and Bartholomew the Englishman, have little or nothing to say on the subject and need not here be considered.

These encyclopaedists drew information from comparatively few sources. One or two texts attributed to Avicenna, the *De Aluminibus et Salibus* formerly attributed to Ar-Razi, a text of "Hermes" now lost, the *Meteorologica* of Aristotle, and the works of certain medical writers are all that they cite; and the resultant theory of metals is a systematisation of these Arabic authors according to the mediaeval version of the ideas of Aristotle. Into that systematisation, however, entered the quite considerable knowledge of metals possessed by the alchemists and technologists, and there emerges an intelligible and reasonable theory. I have not considered it to be my business to trace the actual Arabic authors of these texts: my purpose is to reproduce what the men of the thirteenth century thought—and they thought they were following Avicenna, Rhases, Hermes, and Aristotle: the elucidation of their real sources I leave to the Arabists, for whom I have a respect amounting almost to awe.

The idea of a metal

Metals are not defined by the XIIIth-century authors as a class but rather *per enumerationem*. Malleability was recognised as a common characteristic, for metals are sometimes called "the six that are extended by the hammer", a phrase that many times occurs in one of the texts used by the XIIIth-century encyclopaedists and attributed to Avicenna. The seven metals commonly recognised are gold, silver, copper, lead, tin, iron, and mercury: there is no clear distinction in most texts between *cuprum* (copper) and *aes* (brass), though Albertus is quite clear about the difference. In addition to these we hear of steel, recognised as a modified and purified iron, and orichalcum, considered to be a kind of brass.

It is hard to say whether there was any conception of a "pure" metal. Certainly "very pure gold" is spoken of and the system of grading gold into 24 carats (*carectes*) is mentioned by Bacon (*Opus Majus*) who, however, claims that his "Experimental Science" made it possible to obtain gold of 30 or 40 carats. It seems that there was a standard of gold, which was that refined to the greatest extent then possible, but that the obtaining of gold more excellent than the natural seemed in no way impossible.

The mutual relation of the metals

The most important question concerning metals was that of their relationship. Did the baser metals differ from gold (*a*) as the impure from the pure, (*b*) as the unripe from the ripe, or (*c*) were they of different species, differing

as the dog from the horse ? The former views made alchemy appear a relatively hopeful pursuit, but if there were a real difference of species, it was clearly necessary to reduce the metals to their common matter before this could receive the form of gold.

It was common ground that the metals were one and all compounded of two matters, commonly called mercury and sulphur (*v. infra*). Did the various products of the combination (*mixtio*) of these constituents differ only in purity and maturity or were they separate species ?

Albertus was strongly in favour of the latter view, but he tells us that the experiments of the Alchemists have occasioned serious doubts " For they seem to say that the species of gold is the only form of metals and every other metal is incomplete and still on the way to become gold . . . these metals are sick and they seek the elixir to cure them ". He finds the alchemical books very unsatisfactory and says " I have perused very many alchemical books and I have found them without seal and proof, only attempting to conceal their intention by metaphorical expressions, which has never been the custom of philosophy. Only Avicenna seems to touch on reasons, very scanty, which give us some light for the solution of the said questions ".

Avicenna, he tells us, held that if things had the same proximate elements and the same mode of mixture, they were of the same species, and this Albertus considered was fulfilled by the metals : further, the evidence of transmutation seemed to support this.

Against this view, Albertus pointed out that the metals were permanent in nature and must therefore be supposed to be completed by substantial forms. Moreover, the properties of metals were, in his opinion, too far different to allow of them being mere varieties of the same species.

He then considers the theory, attributed by him to "almost all the alchemists ", that any metal has more than one nature (e.g. that lead is internally gold, and gold internally lead) so that transmutation could be performed by bringing the interior nature to the exterior. It was obvious, he said, that exterior and interior were not used of spatial parts of the metal, but rather that the exterior was " dominant " hiding the " interior " which was dominated. But against this Albertus adduces the fact that lead can be burnt up in the fire and yet leaves no gold behind ; if indeed lead *can* be transformed into gold, the lead is destroyed and the gold formed.

The writer of the *Summa Philosophiae*[1] ascribed to Grosseteste, follows Albertus, from whom his arguments are clearly derived, but Grosseteste himself, in his *Opusculum de Artibus Liberalibus*, comes down firmly on the other side " For all metals ought, of the intention of Nature, to be gold, nor do they differ from gold, except as the imperfect from the perfect ".[2] Bacon does not discuss the question.

The matter of the metals

The metals were never considered to be elements, but to be composed of two or more simpler substances united by " mixtio ". On the question of the nature of the constituents of metals, however, there were several apparently discordant authorities to be reconciled :

1. The normal view that all bodies are composed of all four of the elements, but in different proportions.

[1] Baur, L. *Die Philosophische Werke des Robert Grosseteste Bischofs von Lincoln.* (Beiträge zur Geschichte der Philosophie des Mittelalters. Band IX. Munster-i-W. 1912.)
[2] Ibid. p. 6.

2. The statements of Aristotle[3] and Plato[4] that metals are a kind of water.
3. The statement, also derived from Aristotle, that the metals are formed from two vapours.
4. The theory, found in the works of the Greek alchemists and adopted by Avicenna and the Arabic alchemists in general, that metals are composed of mercury and sulphur.

Many authors, alchemical and otherwise, were content simply to follow Avicenna and account for the metals in terms of various qualities, proportions and degrees of coction of mercury and sulphur, but Albertus Magnus, who interpreted his world, as far as he could, in terms of Aristotle's pronouncement, had to form a harmony of all the ideas listed.

He starts, then, by saying that " following Aristotle, we know that the first matter of all fusible bodies is water ". But the difficulty at once arises that metals may be melted and kept at a red heat without losing their humidity (i.e. their fluid state) whereas water distils over at a low temperature. So the moisture of metals must be more like that of oils and fats ; yet not being inflammable, it must be in some way different. He notes that melted metals do not wet the things on which they are poured and so supposes their moisture is bound within them, closely associated with a subtle earthy matter from which it cannot be separated. He concludes then that *the first matter of metals is a subtle unctuous humidity, which is incorporated with a subtle earthiness and very strongly combined, so that the greater part of each is not only associated with the greatest part of the other, but is even contained in the greatest part of the other* ".[5]

This view was adopted by the author of the *Summa Philosophiae* attributed to Grosseteste, who accounts for the sinking of metals in water by the presence of the heavy earthy constituent.

The above view was readily reconciled with the mercury and sulphur theory, for, as Albertus says, " the humidity of which we spoke, mixed with earth, is the proximate matter of quicksilver and the unctuosity which we described is the proper and essential matter of sulphur ".

The author of the *Summa Philosophiae* develops this theme considerably. Sulphur and mercury are both chiefly water (the one being fusible and the other liquid) but both have also an earthy portion. In his view sulphur contributes the formal part of metals and mercury the material : they therefore play the part of male and female in the generation of the metal.

A third theory, ascribed to Hermes, was that the matter of the metals was a cold, dry, heavy black earth, which was impregnated by the celestial light. Albertus assimilated this opinion by taking it to represent the interaction of the mineral and celestial virtues in the act of mixing of the matters.

Water and earth were, then, the remote matter of metals. It is true that it was generally held that in every body all four elements were present, but the weight and coldness of metals made it evident that the proportion of fire and air in them was negligible. The proximate matter of metals, that from which they were immediately made, was mercury and sulphur. These again were not regarded as pure single substances, as are those elements today, but they could be of many different qualities. Sulphur in particular could be

[3] Aristotle. *Meteorum.* IV. Cap. X. 15. " So gold and silver and bronze and tin and lead and glass and many stones that have no names are of water, for they all liquefy by heat." Although the IV Book of Meteors is not Aristotle's, similar views are expressed in the III Book.

[4] Timaeus : (Cornford's *Plato's Cosmology*—translation p. 248–251, with accompanying discussion).

[5] Albertus. *De Mineralibus.* Lib. III, Cap. II.

more or less earthy and of several different colours, which differences were taken to influence the nature of the metals formed from them.

But it was not only the nature of the matter that determined the nature of the metal formed, but also the circumstances of the combination of the matters.

The generation of metals

The locus classicus bearing on the generation of metals is the fifth chapter of the third Book of Meteors of Aristotle, which is quoted below.

> Some account has now been given of the effects of the secretion above the surface of the earth : we must go on to describe its operation below when it is shut up in the parts of the earth. Just as its twofold nature gives rise to various effects in the upper region, so here it causes two varieties of bodies. For we maintain there are two exhalations, one vaporous, the other smoky, and there correspond two kinds of bodies that originate in the earth, the "fossil"[6] and metals.
>
> For the dry exhalation is that which by burning makes all the "fossil" bodies, such as the kind of stones that cannot be melted, realgar and ochre and ruddle and sulphur and other such things.[7] Most of the fossil bodies are coloured ashes or a stone concreted from them such as cinnabar. The vaporous exhalation is the cause of all metals, fusible or ductile things, such as iron, copper, gold. For the vaporous exhalation, being shut in, makes all these things, and especially when in stones. By their dryness, being compressed and congealed into one thing, just like dew or hoarfrost, when it has been separated it generates these things. Hence these things are water in a sense, and in a sense not. For the matter was that of water potentially, but it is no longer, nor are they from water which has been changed through some affection, such as are juices. For copper and gold are not formed like that, but each of them was formed by the exhalation congealing before water was formed. Wherefore all are affected by fire and have some earth ; for they contain the dry exhalation. But gold alone is not affected by fire.[8]

Albertus expands and explains the passage :—

> The place generates that which is located there, through the properties of heaven, which flow into them through the rays of the stars : for in no place of an element are the rays of all stars found except in the earth, as Ptolemy says, because it is like the insensible centre of the whole celestial sphere, for the greatest virtue of the rays is in the place where all unite and so the earth is productive of many and wonderful things. . . .
>
> The true metal is generated only by a natural sublimation of such a moist body as is mentioned above, and such an earthy body as is mentioned above. For in the place where earthy and watery are first mixed, through the nature of the place, there is everywhere mixed much impure with the pure, which impure is not favourable for the generation of metals. From that hollow place which has in it such a mixture, by virtue of the fume raised therefrom there go out pores small or great, many or few, according to the nature of the stone or earth, in which the fume raised, or vapour for a long time distended, is choked and reflected back into itself ; and since there is in it some of that subtle matter which is mixed, it is

[6] The meaning of the word is simply "anything dug up". Until quite modern times the word simply meant mineral or stone.

[7] Realgar is arsenious sulphide, ochre and ruddle are clayey iron oxides ; all three were used as red pigments.

[8] Aristotle. *Meteorologica.* Book III. Ch. 6. (378c.)

> congealed in that tube and in the pores it is mixed in the fashion of vapour, and converted into the metal of the kind of which the vapour is. This explains the " gangue " found with the metal and also the fact that it is found in veins.[9]

Thus we discover the notion that the earth is a sort of sublimatory in which the vapours of mercury and sulphur passing through the tortuous passages of the rocks are acted on by a concentration of celestial influences.

Factors determining the nature of the metal produced

It was generally held that each metal had its own substantial form, which was the determinant of its characteristic properties. The nature of the particular form depended both on the matter and on the celestial influences.

In an animal or plant-generation, where there was a true seed, this determined the *form* of the species ; and the celestial virtue at the moment of generation only determined the *accidents*. Thus human generation by the nature of the seed produced Man, but the celestial influences determined the innate character of the man. But where there was no seed, as in supposed spontaneous generations, then the celestial virtue acted instead of a seed. Whether the generation of a metal was a generation with a seed or without was a question which does not seem to be argued by the XIIIth-century writers. It would seem that an Aristotelean would consider it to be without, but that the *seminales rationes* of later Greek philosophies might have been considered as determinants of the metals to be produced. The notion that sulphur is instead of a seed would lead to the notion that the kind of metal is determined by the kind of sulphur : while the notion that the celestial virtue so acted would lead to the belief that the celestial aspect would determine the metal formed. This latter view is clearly adopted by Albertus, as is shown in the following passage :

> In the same way there must need be in Nature (which is more certain and direct in her works than any art), as there is in all other things, without doubt a formative virtue and an influx from stars and heaven, which directs to its species the heat digesting the matter of a metal : this heat has correctness and formal virtue from the moving intellect, and effectiveness from the virtue of the light and heat which is caused by the light of the stars and orb, and the virtue of segregating the homogeneous by the virtue of fire. The heat is caused to terminate its work at the form of the metal, by the action of the form of the prime efficient which gives forms in the whole realm of Nature. This is the mover of the orb unfolding the forms of Nature by the motion of the heavens and qualities of elements as the artist unfolds the forms of his art by the chisel and hammer.[10]

In fact both views seem to have been held. Thus Grosseteste[11] attributes the formation of particular metals to the planets alone.

> For when the virtue of the sun moves a pure sulphurous fume, mixing it with quicksilver, and decocts it with a temperate decoction, it becomes gold. And when the coldness of the moon takes possession of the heat of the sun, so that there is but a slight decoction of the aforesaid matters, silver is produced. But if with the heat of the sun is mingled the coldness of Saturn, because it is earthy the sulphurous fume is moved together with earthy impurity and is mixed with a pure quicksilver and is decocted with a slight decoction, and it becomes lead. But if with the

[9] Albertus. De Mineralibus. Lib. III. Cap. X.
[10] Ibid. Cap. IV.
[11] *De Liberalibus Artibus* op. cit. note 1.

heat of the sun is mixed the heat and moisture of Jupiter, the sulphurous fume is moved by its entry and is mixed with a pure quicksilver, but on account of the moisture of Jupiter there is little decoction and tin results. But when with the heat of the sun is mixed the superfluous heat and dryness of Mars, a gross sulphur with a gross quicksilver, it is too much decocted and iron is produced. But the heat of Venus with the heat of the sun, decocting the things last mentioned with a more temperate decoction, but less than the decoction sent out by Mars forms latten. The virtue of Mercury mixing a sulphurous fume with a viscous water makes quicksilver.

On the other hand Alchemical works dating from this period may take no account of the planetary influence. Thus the work[12] attributed to Avicenna and so much used by the XIIIth-century encyclopaedists has the following passage, in which the origin of the metals is discussed.

Of Gold

But the philosophers say that gold is made in the belly of the earth, with great heat in many years, and it is made from fair mercury with a red bright sulphur by coction for 100 years and more . . . .

Of Silver

But silver, so say the philosophers, is made from bright mercury and an orange (*croceo*) sulphur, cocted for a century.

Of Copper

Copper is made from a pure mercury, and from a red sulphur cocted for 100 years.

Of Lead

The philosophers say that it is made beneath the earth from a gross and thickened mercury and from a very bad and impure sulphur, crude and little cocted.

Of Iron

Iron is made under the earth from a thick mercury and a thick red sulphur much cocted.

Thus the author of this text and those who followed him literally, took no account of the influence of the planets in generation but only of the nature of the matter and its degree of coction. Thus Roger Bacon in the *Opus Minus*[13] accounts for the generation of the different metals in this fashion. This difference seems to be reflected in the methods used by the alchemists for transmutation : some consider the hour important (as determining the celestial influences), while others make no mention of the selection of favourable times.

Whether metals can be transmuted

The Latin writers of the XIIIth century are unanimous in believing in the possibility of transmutation. If metals were all of the same species, it was obviously possible to make them into gold : if of different species, it was still possible to reduce them to the common matter and convert this into the metal required. The theoretical possibility was undoubted, though there were some who doubted whether what was made by the alchemists of the time was in fact gold.

Among those who held metals to be all of the same species was Grosseteste who says[14] :—

The other metals differ from gold only in the impurity of their matter

[12] Liber Abvali Abincine de Anima in Arte Alchimiæ *in* Artis Chemicae Principes, Avicenna atque Geber . . . . Basileae. 1572, pp. 32-3.

[13] Rolls Series. Pp. 375 ff.

[14] Loc. cit. Note 1.

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or the inequality of their complexion. Wherefore to transmute them is to clean away the impurities and add to them when cleansed a substance assimilated to the sun in virtue and operation, which brings them back from their state of inequality. This substance is not prepared at any time, but only when the sun is in exaltation free from aspect of evil planets ; which is then in its strength and extracts in the material of this substance virtue assimilated to itself, which it can only bring from potency to act at certain hours.

Albertus Magnus[15] follows the opinion of Avicenna that species are not transmuted unless they are reduced to prime matter or to the matter of metals. He continues :—

> First, some purge much the matter of quicksilver and sulphur and so strengthen their elemental and celestial virtues ; and then Nature operates and not art, except by means of instruments, by helping and expediting.
>
> For what the elemental and celestial virtues do in natural vessels, this they do in artificial vessels, if these artificial vessels be formed in the manner of the natural : and what Nature does by the heat of sun and stars, this art does by the heat of fire : as long as it is so tempered, that it does not exceed the virtue that moves itself and informs what is in the metals : for the celestial virtue, which first mixed it, is present in it : and this is inclined this way or that by the help of art. For the celestial virtue is extremely common, and receives determination by the virtues of those things which are the subject of it, in mixed things : for in this way we see the celestial virtues operative in the whole nature of generated things, particularly in those that are generated by putrefaction.

He goes on to say that the best alchemy is that which works on those things from which Nature proceeds, namely sulphur and mercury. But those who whiten by white things, or make yellow by yellow things, while the species of the metal still remains, do not make true gold and silver : and in this way nearly all the alchemists proceed, wholly or in part :

> On account of which I made to be tried that alchemical gold which had come into my hands and likewise silver ; after it has sustained six or seven fires, at once when further ignited it is consumed and destroyed and returns to a sort of dross.

Thus Albertus distinguishes a true alchemy which follows the generation of metals in nature, from the superficial colouring of metals.

The author of the *Summa Philosophiae* takes a similar view. He believes in transmutation : thus he writes :

> They diversify (metals) artificially by the elixir and vessels appropriate to the places. It is possible that all metals can be made from each other in turn, and sometimes from other matters, though by many alterations and powerful purgations both of sulphur and of mercury.[16]

He is, however, aware of the possibility of mere superficial colourings,

> There are also other colours superinduced on metals, as greenness on bronze by pouring vinegar on it or the urine of a virgin male child, as Hermes witnesses, and other colours in other ways, artifices which the alchemists know but which do not much pertain to philosophy.

Roger Bacon clearly believed in transmutation but his discussions of alchemy in his unquestioned work[17] amount to little more than his usual

[15] Op. cit. note 9. Cap. IX.

[16] Op. cit. note 1. Cap. 10 (279).

[17] *The Speculum Alkimiae* attributed to Bacon is in my opinion to be rejected as not being written in Bacon's very characteristic style. Moreover, Bacon's undoubted works treat alchemy in a rather perfunctory manner which may indicate that he was not much interested in the art.

attitude to contemporary scientists, namely that the alchemists were ignorant and that he, Bacon, knew the true method of making the most excellent kind of gold : but he does not tell us anything about his method.

The source of the properties of metals

Some attempt was made to account for the properties of metals in terms of their supposed composition. The properties of metals to which the writers of the time adverted were as follows :

(1) *Fusibility.* This has already been dealt with and is accounted for by the theory that all metals contain a humid element. That iron is infusible (as then supposed) was accounted for by its great impurity or earthiness.

(2) *High Density.* The presence of an earth in metals accounts for this, together with the notion that the pores of the earth which otherwise might contain the light element, air, were filled with humidity.

(3) *Effect of heat on the metals.* The fact that base metals were destroyed or converted into dross by the fire, whereas gold was unaffected, does not seem to be specifically treated. The explanation implied is that in gold the humid and earthy parts were exactly proportioned and completely bound up with each other, whereas in other metals the binding was less complete so that this humidity could be evaporated in the fire.

(4) *Colour.* The *Summa Philosophiae*[18] has a discussion on the question which is worth quoting :

> It is manifest that there are three special colours in metals. But one is common nor thus determined, which is splendour or *fulgor* ; the second is whiteness ; the third yellowness or reddishness. In whatever therefore there is much " perspicuum " condensed, clear and pure, there is caused splendour and fulgor and also whiteness. Wherein also there are many grades. For silver is the whitest, and following it tin, in the third place lead, and last iron. And so the shining (*nitor*) is caused by the subtle watery matter especially when bounded and condensed, and every metal, the more it has its watery constituent subtler, purer and denser, the more shining and clean it will be when it is polished. Therefore gold shines in the highest degree, secondly silver, thirdly iron, because when purified it shines like a mirror (. . . here follows a brief section on mirrors. . .).
>
> The cause why metals attain to greater or less yellowness is the substance of sulphur colouring them differently, because if the earthy and watery in them is very pure and digested, by the action of sulphur, the colour will be altered into very pure yellow splendour, such as is that of gold ; and if the terrestrial be impure and not well mixed the heat that guides it will burn it, and it is made very yellow by the sulphur, but the splendour on its surface will not last long but little by little will decline to a smoky blackness, as appears in brass and copper. Whiteness is caused in them from the moist, terminated by a subtle earthiness digested, as appears in lime (*calce*) and quicksilver, strongly grasped in the earthy, and the moist well washed and made subtle. Wherefore if the terrestrial have inclined to the side of feculence or impurity or adustion, the innate whiteness will proportionately approach to the side of blackness as happens in the aforesaid four white metals.

[18] Op. cit. note 1. Cap. II (280).

Conclusion

The theory of metals as held in the XIIIth century well illustrates the character of the chemistry of that age. A class of bodies, the metals, is recognised, and it is supposed that these like bodies must have a common origin and constitution. The theory adopted is primarily based on the suppositions of Aristotle and harmonised with the metallurgical and alchemical observations. No attempt is made to go beyond this field, i.e. to study the properties of metals and their compounds, as was done in the XVIIth century ; it was sufficient if the theory was at once consistent with Aristotle's views, real or supposed, and also saved the known phenomena, for the natural philosopher did not seek new phenomena by means of which the theory was to be tested.

As in so many instances the XIIIth-century philosophers began by asking the most difficult questions and ignored the easy ones. They did not wish to prepare and record an account of what happened to each metal under a number of conditions : they were content to start with the common knowledge about the metals and with its slender aid to try to answer the really difficult questions to which science has given answers but recently, if at all. Their interest was in the relationship of metals, the generation and transmutation of metals ; they show but a casual interest in attempts to explain one or two of their obvious properties. May we sum up their attitude, perhaps by saying that they sought a philosophy of metals rather than a chemistry thereof ? And even so, the metals are the best-studied class of bodies in the XIIIth century. Other substances of technological importance, glass, ceramic material, combustibles, soap, receive even less or in some instances no notice from the encyclopaedists. We may suppose, then, that the XIIIth-century encyclopaedists' interest in the metals was due rather to their alchemical and astrological significance than to their technological importance.