was a scepticism from which the thought of Greece did not emerge until Plato, returning to Parmenides, declared the study of the One and the Many, jointly regarded, to be the true office of philo­sophy. Thus, meagre and futile as the doctrine of Thales was, all the Greek schools, with the solitary exception of that of Pytha­goras, took their origin from it. Not in name only, but also in fact, Thales, the first of the Ionian physicists, was the founder of the philosophy of Greece.

Bibliography.—(*a*) *Geometrical and Astronomical.* C. A. Brct- schneider, *Die Geometrie u. die Geometer vor Euklides* (Leipzig, 1870); H. Hankel, *Zur Geschichte der Mathematik* (Leipzig, 1874); G. J. Allman, "Greek Geometry from Thales to Euclid,” *Her­mathena,* No. v. (Dublin, (1877); Μ. Cantor, *Vorlesungen über Geschichte der Mathematik* (Leipzig, 1880); P. Tannery, "Thales de Milet ce qu’il a emprunté à l’Egypte,” *Revue Philosophique,* March 1880; "La Tradition touchant Pythagore, Oenopide, et Thalès,” *Bul. des Sc. Math.,* May 1886; R. Wolf, *Geschichte der Astronomie* (Munich, 1877). See also under Eclipse and Astro­nomy. (*b*) *Philosophical.* The histories of Greek philosophy men­tioned *s.v.* Parmenides. A. B. Krische, *Forschungen,* pp. 34-42 (Göttingen, 1840). (H. Ja.)

**THALLIUM** [symbol Tl, atomic weight 204∙0 (O=16)], a metallic chemical element. It was discovered in 1861 by Sir William Crookes, who, during a spectroscopic examination of the flue-dust produced in the roasting of seleniferous pyrites occurring at Tilkerode in the Harz, observed a green line foreign to all then known spectra. He concluded that the mineral contained a new element, to which he gave the name of thallium, from ϴαλλos, a green twig. Crookes presumed that his thallium was something of the order of sulphur, selenium or tellurium ; but Lamy, who anticipated him in isolating the new element, found it to be a metal. Our knowledge of the chemistry of thallium is based chiefly upon the labours of Crookes.

The chemical character of thallium presents striking pecu­liarities. Dumas once called it the “ *ornithorhynchus paradoxus of* metals.” As an elementary substance, it is very similar in its physical properties to lead; it resembles lead chemically inasmuch as it forms an almost insoluble chloride and an insoluble iodide. But the hydroxide of thallium, in most of its properties, comes very close to the alkali metals; it is strongly basic, forms an insoluble chloroplatinate, and an alum strikingly similar to the corresponding potassium compounds. Yet, unlike potassium or lead, it forms a feebly basic sesquioxide similar to manganic oxide, Mn2O3.

Traces of thallium exist in many kinds of pyrites, as used for vitriol-making. The only known mineral of which it forms an essential component is the rare mineral crookesite of Skri- kerum, Småland, Sweden, which, according to Nordenskiöld, contains 33∙3 per cent. of selenium, 45∙8 per cent. of copper, 3∙7 per cent. of silver, and 17∙2 per cent. of thallium. The best raw materials for the preparation of thallium are the flue-dusts produced industrially in the roasting of thalliferous pyrites and the “ chamber muds ” accumulating in vitriol-chambers wrought with such pyrites; in both it is frequently associated with selenium. The flue-dust from the pyrites of Theux, near Spa (Belgium), according to Böttcher, contains 0∙5 to 0∙75 per cent. of thallium; that of the pyrites of Meggen, according to Carstanjen, as much as 3∙5 per cent.; while that of the pyrites of Ruhrort yielded 1 per cent. of the pure chloride to Gunning.

For the extraction of the metal from chamber mud, the latter is boiled with water, which extracts the thallium as the sulphate. From the filtered solution the thallium is precipitated as the chloride by addition of hydrochloric acid, along, in general, with more or less of lead chloride. The mixed chlorides are boiled down to dryness with sulphuric acid to convert them into sulphates, which are then separated by boiling water, which dissolves only the thallium salt. From the filtered solution the thallium is re­covered, as such, by means of pure metallic zinc, or by electrolysis. The (approximately pure) metallic sponge obtained is washed, made compact by compression, fused in a porcelain crucible in an atmosphere of hydrogen, and cast into sticks.

Metallic thallium is bluish white; it is extremely soft and almost devoid of tenacity and elasticity. Its specific gravity is 11∙86. It fuses at 290° C.; at a white heat it boils and can be distilled in hydrogen gas. Its vapour density at 1728°corresponds to the molecule Tl2. Its salts colour the Bunsen flame a bright green. When heated in air it is readily oxidized, with the formation of a reddish or violet vapour. When ex­posed to the air it becomes quickly covered with a film of oxide; the tarnished metal when plunged into water reassumes its metallic lustre, the oxide film being quickly dissolved. When kept in contact with water and air it is gradually converted into hydroxide, T10H. It decomposes water at a red heat, liberat­ing hydrogen and being itself converted into the hydrate. It is readily soluble in nitric and sulphuric acids, but less so in hydro­chloric.

Thallium forms two series of salts: thallous, in which the metal is monovalent; and thallic, in which it is trivalent. In the thallous series many analogies with lead compounds are observed; in the thallic some resemblance to aluminium and gold.

*Thallous hydroxide,* T10H, is most conveniently prepared by de­composing the solution of the sulphate with baryta water. It crystallizes from its solution in long yellow needles, TIOH or T10H +H2O, which dissolve readily in water, forming an intensely alkaline solution, which acts as a caustic, and like it greedily absorbs carbonic acid from the atmosphere. Unlike the alkalis, it readily loses its water at 100° C. and even at the ordinary tempera­ture, to form the oxide TI2O, which is black or black-violet.

*Thallic oxide,* T1O or TI2O2, was obtained by O. Rabe *(Abst. J.C.S.,* 1907, ii. 769) by acting with hydrogen peroxide on an alkaline solution of thallous sulphate at low temperatures, an initial red precipitate rapidly changing into a bluish-black com­pound. It melts at 720° and decomposes rapidly above 800°, giving oxygen and thallous oxide. *Thallous chloride,* T1C1, is readily obtained from the solution of any thallous salt, by the addition of hydrochloric acid, as a white precipitate similar in appearance to silver chloride, like which it turns violet in the light and fuses below redness into a (yellow) liquid which freezes into **a** horn-like flexible mass. It is also formed when the metal is burnt in chlorine. The specific gravity of this “ horn ” thallium is 7∙02. One part of the precipitated chloride dissolves at 0° C. in 500 parts of water, and in 70 parts at 100° C. It is less soluble in dilute hydrochloric acid. Carbonate of soda solution dissolves it pretty freely. *Thallous iodide,* T1I, is obtained as a yellow precipitate, which requires 16,000 parts of cold water for its solution, by the addition of potassium iodide to a solution of a thallous salt, or by the direct union of its components. The yellow crystals melt at 190°, and when cooled down assume a red colour, which changes to the original yellow on standing. *Thallous bromide,* TlBr, is a light yellow crystalline powder; it is formed analogously to the chloride. *Thallous fluoride,* T1F, forms white glistening octahedra; it is obtained by crystallizing a solution of the carbonate in hydro­fluoric acid. It resembles potassium fluoride in forming an acid salt, T1HF2. *Thallous chloroplatinate,* Tl2PtCl6, readily obtainable from thallous salt solutions by addition of platinum chloride, is a yellow precipitate soluble in no less than 15,600 parts of cold water. *Thallous perchlorate,* TlClO4, and *periodate,* TllO4, are interesting inasmuch as they are isomorphous with the corresponding potassium salts. Other instances of the isomorphism of thallous with potassium salts are the nitrates, phosphates, hydrazoates, sulphates, chromates, selenates, and the analogously constituted double salts, and also the oxalates, racemates and picrates. *Thallous carbonate,* Tl2CO3, more nearly resembles the lithium compound than any other ordinary carbonate. It is produced by the exposure of thallous hydrate to carbon dioxide, and therefore is obtained when the moist metal is exposed to the air. It forms resplendent monoclinic prisms, soluble in water. *Thallous sulphate,* Tl2SO4, forms rhombic prisms, soluble in water, which melt at a red heat with decomposition, sulphur dioxide being evolved. It unites with sulphuric acid giving an acid salt, TlHSO4∙3H2O, and with aluminium, chromium and iron sulphates to form an “ alum.” It also forms double salts of the type Tl2SO4(Mg,Fe,ZnSO4)∙6H2O. *Thallous sulphide,* Tl2S, is obtained as a black precipitate by passing sulphuretted hydrogen into a thallous solution. It is insoluble in water and in the alkalis, but readily dissolves in the mineral acids. On thallium sul­phides see H. Pélabon, *Abst. J.C.S.,* 1907, ii. 770. *Thallous nitrate,* TlNO3, is obtained as white, rhombic prisms by crystallizing a solution of the metal, oxide, carbonate, &c., in nitric acid. Various thallous phosphates are known. The normal salt, Tl3PO4, is soluble in 200 parts of water, and may be obtained by precipitation. On thallous salts see W. Stortenbeker, *Abst. J.C.S.,* 1907, ii. 770. *Thallic oxide,* Tl2O3, is obtained as a dark reddish powder, insoluble in water and alkalis, by plunging molten thallium into oxygen, or by electrolysing water, using a thallium anode. *Thallic hydroxide,* Tl(OH)3, is obtained as a brown precipitate by adding a hot solution of thallous chloride in sodium carbonate to a solution of sodium hypochlorite. On drying it has the composition TlO(OH). Hydrochloric acid gives thallous chloride and chlorine; sulphuric acid gives off oxygen; and on heating it first gives the trioxide and afterwards the monoxide. The hydroxide is obtained as brown hexagonal plates by fusing thallic oxide with potash to which a little water has been added. *Thallic chloride,* TlCl3, is