phenomena of the conversion of iron into steel in the cementation process all point to the conclusion that the carbon is simply absorbed, as the varying rate of impregnation with variations of temperature, the gradual change from the outside to the inside, and the large deposition of free carbon from such steel, if dissolved in hydrochloric acid, or chloride of copper, or cold dilute nitric acid.

As to No. 2, the author adopts the theory of Jullien, that the hardening of steel is due to the crystallisation of the so-called combined carbon (really absorbed) in a form resembling the diamond. He observes that cemented steel only becomes hard when heated and quenched, and that the fracture then shows innumerable small crystals, which, under the microscope, present physical features very much like small diamonds. These crystals do not appear in wrought iron, increase in number as the proportion of carbon increases, and as the hardening increases, and are more numerous at the outside of the piece, where the hardness is also less. They are therefore crystallised carbon, in other words, diamond. Estimations of carbon in the different layers of a piece of hardened steel have always shown that the actual proportions, as formed by combustion, are the same throughout, but that, as examined by the colour test, they increase gradually from the outside to the inside. This shows that some change has taken place in the carbon. The author's theory is that at a red heat the molecules of iron are expanded and partially separated; that in this state the absorbed carbon is partially dissociated from the iron, and upon the steel being suddenly quenched, the carbon is not re-absorbed, but takes up a small amount of hydrogen, and is fixed in the state of diamond. It is known that hydrogen is present in the diamond, and also in steel, and it is submitted that it forms the active agent in reducing the carbon from the amorphous to the crystalline form. On analysing this hardened steel, it is supposed that the crystalline carbon goes off in all cases as gas; so that less "combined carbon will remain to be shown by the colour tests or deposited on solution in hydrochloric acid. It must follow from this view that carbon is the acting hardener of steel, and that the idea of other elements, as phosphorus hardening steel is a delusion. In support of this it is observed that phosphorus does not harden wrought iron and that probably the real effect of phosphorus and silicen is to cause dissociation of carbon, thus producing a larger extent of crystallisation and a harder metal. Thus it is found that the higher the proportion of phosphorus, the greater will be the difference between the carbon, as shown by the colour test, and as fixed by analysis. Again, English Bessemer or Siemens steel will require 20 per cent. less carbon to make it work and harden equally well with best Swedish steel; the explanation being that the phosphorus in the former assists the dissociation and crystallisation. To this effect of phosphorus many of the mysterious failures of steel may probably be traced.

With regard to No. 3, the author regards the variations of tempering as due solely to the completeness, or otherwise, of the decomposition of the crystalline carbon in the hardened steel. He observes that carbon and iron have no action on each other at the heat at which tempering is effected; while, even at such temperatures, the abstraction of hydrogen from carbon, in the presence of iron, cannot be deemed impossible. The tempering of steel by simply quenching it in hot water or oil, may thus be explained; the outer layers may be supposed to be hardened at first in the ordinary way, but then, as the interior heat does not pass away so rapidly, it has time to act on the crystalline carbon, and partly to dissociate it again, thus producing something between hardened and unhardened steel—in other words, tempered steel. The crystallised carbon in the hardened steel is supposed to be diffused in a state of molecular disaggregation, and to be less intimately united with the iron than before hardening.

As to No. 4, the startling statement that the ultimate strength of steel is very little dependent on its amount of carbon, is explained to refer to the strength as calculated upon the fractured area, not the original area. It is, therefore, equivalent to saying that the contraction of the fractured area in iron or steel is proportional to the diameter of ultimate strength. The author finds that this is the case, both in the various published tables of tensile strength of steel, and in his own experiments. Hence he holds that the contraction of area should be taken as the proper measure of ductility (as is usual on the Continent), and not the elongation. He looks upon hard steel as a metal of a certain strength, having diffused through its mass a greater or less number of particles of a very hard and rigid substance. Hence, as ductility means the power of contracting in area, and extending in length by molecular flow, the ductility will be less as flow is more difficult; and flow will be more difficult as there are more of the rigid crystals in the mass. The apparent strength per unit of original area is thus increased; but the strength per unit of fractured area is usually diminished, probably because the hard sharp crystals tend to cut the metal between them, and produce a sort of tearing action. For these reasons the use of ductile and mild steel, in structures of every kind, is much to be preferred to that of a brittle material, though of a higher apparent tenacity.

A CHAPTER IN THE HISTORY OF CONIFERÆ

THE ABIETINEÆ

THE most recent classification of the *Abietineæ*, and the one that will probably be chiefly adhered to, at least in England, is published in the "Genera Plantarum" of Bentham and Hooker, 1880. In it *Pinus*, *Cedrus*, *Picea*, *Tsuga*, *Pseudotsuga*, *Abies*, and *Larix*, are recognised as separate genera. The tribe comprises the cedars, larches, firs, pines, and contains some 150 species, and is almost exclusively confined to northern and north temperate regions. The genera are all cone-bearing, and with few exceptions produce winged samaroid seeds. No definite remains are known of earlier age than Jurassic, but with the Wealden and Cretaceous they become plentiful, and already in the Neocomian and Gault the ancestors of several existing genera were completely differentiated.

Pinus, Linn.—The cones in this genus vary from the size of a walnut to a length of 19 inches, or possibly even more. The scales are woody and persistent, and closed until the seeds are ripened, when they gape widely. The seeds are in pairs under each scale, and, with few exceptions, winged. The leaves are acicular, and in some cases very long, and are sheathed in bundles of two, three, or five. Nearly all classifications are mainly founded on the number of leaves that occur in a fasciculus, but this character is rejected in the "Genera Plantarum" as inconstant. Two natural divisions are, however admitted—*Pinaster* and *Strobus*.

The former and larger division is distinguished by the scales being very closely adpressed before shedding the seeds, and by their quadrate, umbonate, or elongate, conical heads. The *Strobus* section is comparatively small, and has elongated, often pointed cones, with hard and rigid, yet scarcely woody, loosely imbricated scales, thicker centrally than at the margins, and terminating in a minute or obsolete umbo. Cones of *P. strobus* and *P. excelsa*, representing this section, may be picked up in most botanical gardens, while the *Pinaster* section comprises all the pines commonly grown in plantations.

Besides the "Genera Plantarum," many excellent accounts of the tribe have recently been published. Among these are Gordon's "Pinetum" (1880), Veitch's "Manual of the Coniferæ" (1881), Dr. Maxwell Masters' "Coniferæ of Japan" (*Linn. Trans.* 1881), and an exquisitely illustrated essay on the "Coniferous Forests of the Sierra Nevada," in *Scribner's Magazine*, also in 1881.

Of the *Pinaster* division seventy-seven fossil species were enumerated by Schimper; none, however, are definitely assigned to the group from deposits older than the Eocene of Aix, and most are from the upper Miocene, and even later deposits. The oldest forms are from Solenhofen, and the Gault of Hainault is said to contain connecting-links between the two sections.

Of the *Strobus* division twenty species are enumerated, the oldest being from the Komeschichten of Greenland; but there are a number of additional species which cannot well be grouped in either section.

In England no cones are known that can be referred to Pinus, as now restricted, from rocks older than the Purbeck, but their number gradually increases until the close of the Tertiaries.

Seven species of pine are known from our British Eocenes. They are enumerated here for the first time:—

P. Prestwichii, sp. nov. mihi	Woolwich and Reading Beds.
P. macrocephalus, (Lind. and Hutton)	
P. ovata, (id.)	
P. Dixoni, Bowerbank	Bracklesham to Bembridge.
P. Bowerbankii, Can.	London Clay to Bracklesham.
P. Plutoni, Baily	Eocene of Antrim.
P. Graingeri, id.	

I am not sure that the two latter may not be identical with species already described abroad, but they seem distinct from the other British species.

It will be remarked that all the English species are from marine or estuarine deposits, and it is a singular fact that no trace whatever of leaves or fruit of the Abietineæ have been found in those plant beds of freshwater origin in England, which have recently yielded such exceedingly rich floras. It is equally strange that all our Eocene cones from the London clay and strata beneath have been imbedded before shedding their seed, while those from the Middle and Upper Eocenes are gaping and seedless. If inference upon such slender ground were permissible, it would seem as if those that were imbedded during the cooler Lower Eocene period had grown near to where they were imbedded, and their leaves may yet be found in our little-known Lower Eocene floras, while those that were imbedded during the hottest Eocene periods had drifted a long way. The well-ascertained absence of pine foliage during the Middle Eocene in England, and the constantly-decayed condition of the cones, are the data upon which this view may be grounded. Farther north, at Antrim, as we should anticipate, the cones seem more perfect.

It appears desirable to test the relative length of time that ripe and unripe pine cones, seeds and foliage will float, especially in sea-water, and the length of time required to reduce them to the decayed condition of the Barton and Bracklesham specimens, and it is to be hoped that some one possessiug facilities, will undertake experiments.

It will also be interesting to trace out why cones so frequently fall in a closed unripe condition. A Bournemouth resident writes to me that it takes three years for the cone to come to perfection, and that if it remains on the tree all that time, the scales open wide as it hangs, beginning at the base, and making a plainly audible crackling noise as they separate. This occurs chiefly on sunny summer days. The seeds being liberated, either fall or are picked out by tom-tits.

CEDRUS.—Only four species, or varieties according to some, are known—the Himalayan, Lebanon, Atlas, and Cyprus cedars. The cones are globose and erect on the upper side of the branches. The scales are thin, leathery, and closely pressed together, and persist for some time after the seeds are shed. The cones break up on the trees, and fall piecemeal, the scales falling separately, except near the apex, where they remain together as a rosette. This habit may account for the absence of fossil cedars in the Tertiaries, the older forms from the Greensand of Shanklin and Maidstone having possibly possessed a different habit.

PICEA has twelve to twenty-four species. The leaves are solitary, acicular, and more or less in two rows, while the cones somewhat resemble those of the cedar. They inhabit temperate regions throughout the northern hemisphere, almost to the confines of vegetation. Two Gault forms from Hainault are doubtfully referred to the genus, while fossil species are met with in Iceland and Greenland, the Wetterau, the amber-beds, and a few other Miocene localities.

TSUGA possesses five species. The leaves are not very different to those of Picea, and the cones are like those of Cedrus, but pendent and terminal, persisting for several years, and with scales more loosely imbricated and persistent. They inhabit Japan, the Himalayas, and North America, and have been found fossil in the same beds as Picea. *Pinus Crameri*, Heer, related to Tsuga, is the most widely-spread fossil in the Arctic Cretaceous.

PSEUDOTSUGA has only one species, inhabiting from Mexico to Oregon.

ABIES contains eighteen species. The scales are leathery, loosely imbricated, and fall with the seeds and the leaves, as in Tsuga. It extends over the northern temperate regions of both hemispheres, chiefly in mountainous districts. It is known from the Wealden, and even Jurassic, and from Greenland, Iceland, and in European Miocenes.

LARIX possesses seven to ten species. The cones are small, with leathery persistent scales, and fall in clusters with the dead branches. The leaves are linear, solitary, or in bundles, and deciduous in all but one species. The larch extends over the colder regions of Europe, Asia, and America. But four fossil forms have been noticed—three from the Miocene of Francfort, and one from Austria.

The Abietineæ in the existing state in northern regions of Europe, Asia, and America, outnumber the broad-leaved trees by ten to one, for pine-barrens in North America stretch 300 to 500 miles uninterruptedly, and, in the Old World, form a nearly continuous belt from Scandinavia to the east coast of Asia.

Some grow to gigantic size. Sections from two American species of Abies, two of Picea, and one of Pinus, have been exhibited, and officially stated to have been cut from trees considerably over 300 feet in height. In the Himalayas, the cedar and *Pinus excelsa* exceed 200 feet, and other species almost rival these, and even in Europe the heights of several species have been stated at from 120 to 180 feet. The greatest longevity ascribed to any of the Abietineæ belongs to the cedars, which have been estimated at from 600 to 900 years old.

Many of the species are exceptionally hardy, and pass the Arctic circle, and the larch in Siberia extends, as a trailing shrub, to latitude 52°. In Mexico, pines grow at an elevation of nearly 13,000 feet, and in Central Asia, of 10,000 feet.

The economic value of the Abietineæ surpasses that of all other forest-trees, and they supply a very large proportion of the timber in use. Their wood is valuable for all purposes, and some of it is of immense durability, while the money value of that imported into England alone is 9,000,000*l*. per annum, exclusive of other products, such as pitch and tar, which reach nearly another million. The nuts of some species of pine are used as food, and the bark, woody fibre, and secretions are more or less utilised in different countries, and for most varied purposes. Only one species of the whole family is indigenous to England, *Pinus Sylvestris*, the common Scotch pine. the larch and the spruce having been introduced, though both were, I believe, indigenous here in the Pliocene age.

J. STARKIE GARDNER

THE BRUSSELS CHRONOGRAPH

ON November 18, 1880, a description was given in NATURE of certain great galvanic chronographs which were then being constructed by Messrs. E. Dent and Co., of the Strand and Royal Exchange, London. The second of these instruments—that for the Royal Observatory of Brussels—has now been completed. The arrangements for pricking upon the chronograph barrel are much improved, and as they overcome a serious constructive difficulty, we propose to give some account of them.

It will be remembered that the main feature in the