effects of heat and cold upon the figure of the mirrors. This circumstance has called forth a particular investigation, in which heated bodies were approached at different distances, both before and behind mirrors, either of glass or metal; and it was remarkable how their focal lengths were immediately affected by it. Hence it may reasonably be inferred, that the rays of the sun on a mirror will produce a similar distortion. That the dilatation occasioned by heat is the cause of this defect, will easily be admitted; but our author does not enter here upon the theory of this influence, nor upon the remedies that may be applied to its detrimental consequences. These points he reserves for a future communication.

An Account of some Experiments and Observations on the constituent Parts of certain astringent Vegetables; and on their Operation in Tanning. *By* Humphry Davy, *Esq. Professor of Chemistry in the Royal Institution. Communicated by the Right Hon. Sir* Joseph Banks, *Bart. K.B. P.R.S.* Read February 24, 1803. [*Phil. Trans.* 1803, *p.* 233.]

The importance of the subject handled in this paper, which, as it particularly relates to the process of tanning leather, will be allowed to be of sufficient magnitude, has of late excited the attention of several able philosophers, among whom Mr. Seguin was the first who ascertained the peculiar vegetable matter which is essential to this process, and which is possessed of the characteristic property of precipitating gelatine from its solutions. Mr. Proust has since investigated many other properties of this substance; but neither these, nor any other chemists, have as yet carried their investigations so far as to determine the various affinities of tannin, and especially how its action upon animal matters is modified by combination with other substances. This task was reserved for our author, who during the two last years bestowed most of his leisure hours on a course of experiments on this subject; and he here lays before the Society an account of their general results. His chief design was to elucidate the practical part of the process; but in pursuing it he found himself necessarily led to general chemical inquiries concerning the analysis of the different vegetable substances containing tannin, and their peculiar properties.

The paper consists of five parts, the titles of which are as follows:—1. Observations on the analysis of astringent vegetable infusions. 2. Experiments on the infusions of galls. 3. Experiments and observations on the extracts of Catechu, or Terra Japonica. 4. Experiments and observations on the astringent infusions of barks, and other vegetable productions; and 5. General observations.

And first, as to the analysis of astringent vegetable infusions; the substances that have been supposed to exist most generally in them are tannin, gallic acid, and extractive matter. The presence of tannin in an infusion is denoted by the precipitate it forms with gelatine, such as glue or isinglass; but the process requires many and

very delicate precautions: previous to the experiments the infusions are materially affected by exposure to the atmosphere; the tanning principle in different vegetables demands for its saturation different proportions of gelatine; and the quantity of the precipitate obtained by filtration is not always proportionate to the quantity of tannin and gelatine in the solution, but is materially influenced by the degree of their concentration. Hence it follows that the solutions of gelatine, for the purposes of analysis, should be employed in as high a state of saturation as is compatible with their perfect fluidity. They should be used only when quite fresh; and as their relative effects were found to be influenced by their temperature, it was found expedient to bring them, and the infusions on which they were designed to act, as nearly as possible, to a common degree of heat: great care must also be taken to prevent any excess of gelatine. Duly attending to all these precautions, the general result is, that in any given case, when the quantity of gelatine in the solution employed upon an astringent infusion is compared with the quantity of the precipitate obtained, the difference between them may be considered as the proportion of tannin contained in the infusion.

The tannin being thus separated, it remained to ascertain the proportion of the two other ingredients in the infusion, viz. the gallic acid, and the extractive matter. The first step here was slow evaporation, by which the latter substance is in part rendered insoluble, so as to subside at the bottom of the vessel. A proportionate quantity of alcohol being next poured upon the fluid thus reduced to a thick consistency, both the gallic acid and the soluble extractive matter, if there be any remaining in the infusion, will be dissolved. The great difficulty now was to separate the gallic acid and the extractive matter. Ether and alumine were tried without the desired effect, the affinities of these two agents with those substances not being sufficiently distinct to produce the separation. Some judgement, however, may be formed of their relative proportions, by means of the salts of alumine and the oxygenated salts of iron. Muriate of alumine precipitates much of the extractive matter from solutions, without acting materially upon gallic acid; and after this precipitation, some idea may be formed concerning the quantity of the gallic acid, by the colour it gives with the oxygenated sulphate of iron.

2. *Concerning the Infusions of Galls.*—The strongest solution of gall-nuts was obtained by repeatedly pouring distilled water upon the best Aleppo galls, broken into small pieces; it was of the specific gravity 1·068. 400 grains of this solution produced by evaporation 53 grains of solid matter, which, as well as could be estimated by the methods of analysis described in the preceding section, consisted of about $\frac{9}{10}$ths of gallic acid, united to a minute portion of extractive matter. 100 grains, moreover, of this solid matter left, after incineration, nearly $4\frac{3}{4}$ grains of ashes, which were a mixture of lime with carbonate of lime, and a small portion of fixed alkali.

Here follows a long series of experiments on the infusion of gall-nuts, in which it was exposed to, or combined with, all manner of

chemical agents, viz. the sulphuric, muriatic, and nitric acids, potash, soda, ammonia, and a variety of alkaline earths, magnesia, alumine, different solutions of neutral salts, metallic oxides and solutions, and other substances, the list of which is too long to be here inserted. Many of the results may be considered as insulated facts; but those who attend to inquiries of this nature, will find most of them connected with useful conclusions, tending to elucidate this obscure, but no doubt very interesting part of chemistry. The ultimate result of those experiments, as to the constituent parts of gall-nuts, is, that 500 grains of good Aleppo nuts gave by lixiviation with pure water, till all the soluble parts were taken up, 185 grains of solid matter, and that this matter, examined by analysis, consisted of 130 grains of tannin; 35 grains of gallic acid, with a little extractive matter; 12 grains of mucilage, and matter rendered insoluble by evaporation, and the remaining 8 grains of calcareous earth and saline matter.

3. *On the Extracts of Catechu, or Terra Japonica.*—This extract is said to be obtained from the wood of a species of the Mimosa, which is found abundantly in India, by decoction and subsequent evaporation. There are two kinds, the one sent from Bombay, and the other from Bengal. They somewhat differ from each other in their external appearance, but very little, it seems, in their chemical composition. The tastes of both are sensibly astringent; and neither of them deliquesces, or is apparently changed by exposure to air.

Our President was the first who, noticing the more obvious qualities of this substance, suspected that it contained the tanning principle; and being possessed of a sufficient quantity, he was pleased to supply Mr. Davy with all he wanted for the purpose of a chemical examination. The first experiments showed that its solution copiously precipitated gelatine, and that it speedily tanned skin. And hence he was encouraged to undertake the particular investigation of its properties, the account of which is the subject of the present section.

His mode of proceeding, of course, could not differ materially from that which he adopted in the analysis of the gall-nuts. And indeed most of the same, and some additional chemical agents, have been put to the test. The ultimate analysis has been attended with some difficulty, different specimens of this substance, though to all appearance ever so pure, differing materially among themselves; the natives, for the sake of profit, being apt to adulterate what they sell, either with sand, earthy substances, or other extraneous matter.

Mr. Davy, in order to obviate this difficulty, selected a number of specimens, such as he had reason to think the least tainted, and having reduced them into powder, he found the two sorts to consist of the following ingredients:—200 grains of the extract of catechu from Bombay consisted of 109 grains of tannin, 68 grains of a peculiar extractive matter, 13 grains of mucilage, and 10 grains of residual matter, chiefly sand and calcareous earth. The same quantity of the extract from Bengal yielded 97 grains of tannin, 73 grains of peculiar extractive matter, 16 grains of mucilage, and 14 of residual

matter; viz. sand, with a small quantity of calcareous and aluminous earth.

The importance of the object will, we trust, justify our inserting here what our author has ascertained concerning the application of this substance to tanning. Of two pieces of calf-skin, he tells us, which weighed when dry 132 grains each, and which had been prepared for tanning: one was immersed in a large quantity of the infusion of extract of catechu from Bengal, and the other in an equal portion of the infusion of the extract from Bombay. In less than a month they were both found converted into leather. When freed from moisture by long exposure in the sunshine, they were weighed. The first piece had gained about 34 grains, and the second piece 35½ grains. The colour of the leather was much deeper than that tanned with galls, and on the upper surface it was of a reddish brown. It was not acted on by hot or cold water; and its apparent strength was the same as that of similar leather tanned in the usual manner.

4. *On the Infusions of Barks, and other vegetable productions.*—The experiments described in this section were chiefly made on the strongest infusions of the barks of oak, Leicester willow, and Spanish chestnut: each of them were nearly of the specific gravity denoted by 1·05. Their tastes were alike, strongly astringent: 200 grains of each, on being submitted to evaporation, yielded,—the oak bark 17 grains, and the two other barks about 16½ grains of solid matter; and the tannin afforded by these substances were,—the oak bark 14 grains, the willow bark 14½ grains, and the Spanish chestnut 13 grains. These substances also gave by incineration only a very small quantity of ashes, scarcely $\frac{1}{150}$th part of their original weights; and these ashes consisted chiefly of calcareous earth and alkali, the quantity being greatest from the matter produced from the chestnut bark.

These several infusions were acted on by the acids and pure alkalies in a manner very similar to that adopted with the infusion of galls. No gallic acid whatever could be obtained from any of them; and if any be contained in them, it is imagined that it must be in a state of intimate combination with extractive matter. The proportions of the astringent principle in barks vary considerably according to the age and size of the trees from whence they are taken, and probably also according to the different seasons in which they are gathered. In every astringent bark the interior white part (that is the part next to the wood) contains the largest quantity of tannin: the proportion of extractive matter is generally greatest in the middle or coloured part; but the epidermis seldom furnishes either tannin or extractive matter. A few other circumstances are here added, which ought to influence tanners in the choice of their barks.

The other vegetable infusions examined by Mr. Davy were those of the barks of elm and common willow, of sumach, Mirabola nuts, tea, and some other vegetables of known astringent qualities. The results offer no very material differences; but in general the author remarks, that in all substances possessed of an astringent taste, there is great reason to suspect the existence of tannin; that it may be

found in fruits, in which it is modified by sugar and acids; that he has found it in great abundance in the juice of sloes, and that a friend of his had discovered its presence even in port wine. It also appears that it may exist in a state of combination in different substances, in which its presence cannot be made evident by the common means of solutions of gelatine; and that in these cases, in order to detect its existence, it may be necessary to have recourse to the action of diluted acids.

General Observations.—After a few strictures concerning a conjecture of Mr. Proust, that there are different species of the tanning principle possessed of different properties, and different powers of acting upon re-agents, from which our author thinks himself authorized to dissent, he draws the general conclusion,—that in all the different astringent infusions the tanning principle is found possessed of the same general properties and powers of combination. In all instances it is capable of entering into union with the acids, alkalies, and earths; and of forming insoluble compounds with gelatine and with skin. That in the processes of tanning, if the astringent infusion contain extractive and colouring matter, these as well as tannin enter into chemical combination with the skin; but that in no case is there any reason to believe that gallic acid is absorbed in this process. That hence the different qualities of leather made with the same kind of skin, seem to depend very much upon the different quantities of extractive and colouring matter it contains; the leather prepared by means of infusions of galls being generally found harder, and more liable to crack than that obtained from the infusions of bark.

When skins are slowly tanned in weak solutions of the barks, or of extract of catechu, it combines with a considerable proportion of extractive matter, whereby it is rendered perfectly insoluble in water, and yet soft and very strong. The inference, perhaps the most essential, deduced from this inquiry is, that of all the astringent substances as yet examined, the extracts of catechu are those that contain the largest proportion of tannin, half a pound of this extract being found to produce the same effect in tanning as from four to five pounds of common oak bark.

How material this must be in a country where oak timber is not an object of trivial importance, need not be here insisted upon.—The paper closes with a table, in which oak bark being taken as the standard of comparison as to its quantity of tannin, the different astringent substances are arranged in the order of their powers.

Account of some Experiments on the Descent of the Sap in Trees. In a Letter from Thomas Andrew Knight, *Esq. to the Right Hon. Sir* Joseph Banks, *Bart. K.B. P.R.S.* Read April 21, 1803. [*Phil. Trans.* 1803, *p.* 277.]

In a former paper Mr. Knight related some experiments on trees, from which he inferred that their sap, having been absorbed by the