

I may now discuss the third meritorious feature which Dr. Daughlish regarded as a conspicuous advantage possessed by his process—a view which is now endorsed by Dr. Richardson. We are told that “in brown bread, which contains the envelopes or coverings of the whole grain, the flesh-formers amount to 10 per cent., and that, while it is possible to live upon brown bread, without any other food, the health suffers, and death finally ensues, on white bread alone.” “The flesh-formers in white bread amount,” we are told, “to 7 or 8 per cent.” Now by the use of the aerating process, a light and palatable loaf may undoubtedly be readily made, either from the entire meal of crushed wheat, or from such meal from which nothing but the long or coarse bran has been excluded. Such a result cannot be secured with any degree of certainty when yeast is used. This is quite true. But it is not by any means an ascertained fact that brown bread or whole meal bread contains a larger proportion of flesh-formers than white bread from the same wheat. If we make no deduction on account of insoluble and inaccessible flesh-formers in the coverings of the grain, we shall have to make a very considerable deduction on account of nitrogenous matters which are not really albuminoid or flesh-forming, and which are extensively present in the coats which form the main substance of pollard and sharps. We can hardly attribute flesh-forming properties to the “diastase,” “cerealin,” and other obscure nitrogenous ferments which we know to abound in the coarser mill products. Now these are the very bodies which the aerating process enables us to include in our bread without making it heavy, the very bodies whose presence contributes most largely to raise the percentage of assumed flesh-formers, from the 7 or 8 per cent. in white bread to the 10 per cent. in real brown bread. Now, although we have no absolute method of distinguishing between the true flesh-forming nitrogenous bodies in food-stuffs and those whose value is at the best problematical, yet the “carbolic acid process” which I devised in 1873, and which has latterly been attracting a good deal of attention, furnishes some instructive results when applied to the various mill products of the cereals. For instance, I found (in 1875) that pearl barley contains at least 92 per cent. of its nitrogen in the form of genuine coagulable albuminoids, but that “fine dust,” consisting of the richest parts of the barley grains, though it contains three times as much nitrogen as pearl barley, does not contain twice as much unmistakable flesh-forming substance. A similar observation was made on comparing the coverings of the wheat grain with the flour—93 parts out of every 100 of nitrogen in ordinary wheaten flour being certainly in the form of flesh-producers, while the proportion in the entire bran sinks to an average of 72, and sometimes touches a much lower figure. The same result has been obtained with a large number of food materials, in some succulent vegetables the albuminoid nitrogen not exceeding one-fifth of the whole.

It is evident, from the preceding considerations, that whatever be the nutritive or medicinal merits of whole-meal bread, it cannot be definitely stated to be a much richer food so far as flesh-formers are concerned, than white bread made from the flour of the same sample of wheat grain. If we deduct from the supposed 10 per cent. of flesh-formers in whole meal bread $\frac{1}{3}$ or 2 per cent. because of the existence of non-albuminoid nitrogen in the branny particles, and because of the indigestible condition of a small part of the true albuminoids, we leave but 8 per cent. a proportion which does not greatly exceed the 7 or 7 $\frac{1}{2}$ per cent. usually attributed to white wheaten bread.

On some future occasion I may have a few words to say, should the Editor of NATURE accord his permission, as to the bread question treated of in the “Dieteries of Prisons’ Report,” lately presented to Parliament.

A. H. CHURCH

ON THE COMBUSTION OF DIFFERENT KINDS OF FUEL

OUR attention has been called to this subject on perusing a paper read before the American Institute of Mining Engineers. In this communication it is attempted to be proved, that the manner in which charcoal unites with oxygen in iron furnaces, explains its alleged superiority over mineral coal.

The question appears to us to involve considerations outside the mere technical limits of iron smelting. We therefore submit the following remarks, which have been prepared at our request, by a gentleman whose important researches on the economic application of fuel in the smelting of iron are known to all the world.—ED. NATURE.

Prof. John A. Church, of Columbus, states, in a recent publication, “that it is a well-known fact that under similar conditions a ton of pig-iron can be made from any ore with less fuel when charcoal is used than when coke or anthracite is employed for heating.” He then discards, as untenable, all former explanations of this doctrine proceeding either from scientific or practical men, and maintains that “the highest carbon duty is given by the fuel which withdraws the most oxygen from the blast in a given time.”

The professor afterwards proceeds to explain that charcoal, being highly porous, presents a more extended surface to the action of the oxygen than the more compact forms of carbon as it exists in coke or anthracite. He then considers the effect of what is designated in the paper as diluted oxygen on its way to the upper regions of the blast furnace.

In this latter statement with regard to free oxygen, it seems to be overlooked that whatever difficulty this gas may have in attacking dense carbon, there can be no reason why carbonic oxide, generated from coke or anthracite, should not be as easily burnt to the state of carbonic acid as the same carbonic oxide is burnt when formed by the combustion of charcoal.

If it could be shown that all the carbon consumed in the hearth of the blast furnace were in the condition of carbonic acid, then, no doubt, free oxygen might be expected there, but in the presence of so vast a volume of inflammable carbonic oxide in that region such a condition of things is scarcely possible.

It is unnecessary, however, to occupy space with merely speculative matter when actual analyses inform us that in a furnace using coke, not only is there no free oxygen at a very short distance from the tuyeres, but that there is no carbonic acid. In point of fact the whole of the gaseous carbon exists there in the form of carbonic oxide.

Admitting, then, the highest carbon duty to be dependent on the law laid down in the paper, it is clear that at a distance of two or three feet from the point where the blast enters, the conditions in this respect of a furnace burning charcoal or coke are the same.

Prof. Church quotes, in the course of his observations, the results obtained from two furnaces, one using charcoal the other anthracite, and from these he infers that there is an “inherent difference” between the two kinds of fuel of 900 lbs. per ton of iron in favour of charcoal. This figure is a mighty one when it is considered that the charcoal actually consumed for each ton of pig is under 1,800 lbs.

Somewhat inconsistent with this conclusion is the instance quoted of a Lake Champlain furnace, where the consumption of anthracite has been reduced nearly 25 per cent. below that quantity which formed the basis upon which the “inherent difference” was estimated.

The paper further recommends as a reasonable consequence of the superiority of charcoal over coke, that iron manufacturers should, as far as possible, imitate the physical structure of the former in the produce of their

coke ovens. Our "perversity" in preferring hard to soft coke is condemned, and we are invited to put reason in the room of traditions which have not "one recorded fact to sustain them."

My attention, as an iron-smelter, was drawn to the very small consumption of charcoal in a certain instance quoted by Prof. Tunner, of Leoben, and being unable to reconcile his experience with my own observations, I obtained from this respected authority further confirmation of the exactness of his figures. Along with this he kindly repeated his analyses, including one not given in his original paper, viz., that of the gases taken on leaving the furnace, in other words, after they had *completed* their work.

Other investigations prevented my examining the question at the time with that attention it deserved, and I concluded, upon other grounds than those advanced by Prof. Church, that there was some actual difference in the mode in which charcoal effected the reduction of at least some ores.

In this I now think that I was mistaken, and I will endeavour to prove that the author of the paper commits a grave error in comparing two blast-furnaces working upon different kinds and quantities of ores and flux used in the production of pig-iron. I will also attempt to demonstrate that the use of hard coke, held to with such "singular perversity," can be maintained by "reason" as well as by "tradition."

Carbonic oxide, as is well understood, is the chief reducing agent in the smelting of iron, and for our present purpose we may regard it as the only substance which deprives the metal, as it exists in ores, of its oxygen. The carbonic acid which is formed by this deoxidising action possesses a tendency, at certain temperatures, diametrically opposed to that of the lower oxide of carbon—it reoxidises the iron.

This conflicting property of the carbonic acid is kept in check, in iron smelting, by the presence of carbon in the form of its lower oxide, being about double that which is present in its highest form of oxidation.

When I came to examine the ratio in which the carbon in these two conditions existed in the escaping gases, as described privately by Prof. Tunner, I observed that they agreed very nearly with that which I imagine constitutes, in furnaces using coke, a state of equilibrium between the gases and the ore in the process of reduction.

Now no one will dispute that when two pounds of carbon are burnt to the state of carbonic oxide and one pound to the form of carbonic acid the quantity of heat is the same, from whatever source the carbon itself may be derived.

If, after having determined a perfect resemblance between the extent to which the fuel has been oxidized, in the furnace, when using charcoal and using coke, we find that there is no difference in the amount of heat wasted, it is time to consider whether the pig-iron itself, obtained by means of these two kinds of fuel, may not require very different quantities of heat for its production.

It may be here stated that the Cleveland furnaces in England, with which I compared those of Carinthia, were consuming 21 to 22 cwts. of coke against 14 or 15 cwts. of charcoal used in the latter per ton of iron. The weight of the slag produced in the former was very much the larger of the two. The additional heat absorbed in fusing this substance was further augmented by that required for the decomposition of silica and phosphoric acid, the bases of which are found more largely in Cleveland than in Carinthian pig. The diminished quantity of fuel burnt in the charcoal furnaces reduces very greatly the weight of gases, and this consequently lessens the amount of heat carried away through their instrumentality.

The following figures exhibit the number of centigrade heat units required, according to my calculations, per unit of each kind of pig-iron referred to.

	Cleveland iron.	Carinthian iron.
Evaporation of water in fuel	15	15
Reduction of oxide of iron and dissociation of carbonic oxide	1730	1730
Expulsion of carbonic acid from carbonate of lime	250	25
Decomposition of this carbonic acid	265	25
" water in blast	130	75
" silica and phosphoric acid	200	50
Fusion of iron	330	330
" slag	830	330
Loss by radiation	270	200
Carried off in gases	440	210
	4460	2990

Now when the proportions between the heat requirements and fuel-consumption come to be examined, we find that the two sets of numbers agree almost exactly; for—

$$4460 : 2990 :: 21 : 14 \cdot 08$$

Since writing on this question, nearly seven years ago, I have had frequent opportunities of examining the performance of charcoal-furnaces in Sweden, Italy, and Spain, as well as in Virginia, Kentucky, Ohio, Missouri, and Michigan, in the United States. I soon became aware that different kinds of ores demanded very different quantities of charcoal for their treatment. In some cases the weight was nearly as low as that consumed in Carinthia, in others it was quite as much as if coke had been the fuel employed. I failed on every occasion to detect any circumstance beyond the change in the ore itself, or in the nature of the iron it afforded, to which I could ascribe the difference in question. All doubt, however, on the supposed difference of value between the vegetable and mineral fuel was dispelled on receiving from the owners of works in the North of Spain and in Virginia, statements from their books exhibiting the smelting of the same ores with the two kinds of fuel. The difference in these was often in favour of the coke, but such difference as existed could easily be accounted for by fluctuations in the amount of foreign matter in the fuel, or in small changes in the quality of the ores.

It only remains for me briefly to mention the grounds upon which, for chemical reasons, hard coke may be superior to that softer variety recommended by Prof. Church.

Carbonic acid, as is pointed out in the paper by this author, possesses the power of dissolving carbon, and every pound so dissolved involves a double loss. There is a reduction of temperature where the action takes place, and there is a pound less of fuel remaining to be burnt at the tuyeres. I ascertained, however, by direct experiment, that all forms of carbon are not equally easily affected by carbonic acid, that in hard coke being capable of resisting the solvent action much better than the same carbon as it occurs in soft coke. The importance, therefore, of employing our fuel in that condition where it is least susceptible of being oxidized in the region of the furnace where its combustion is useless, need not be further insisted on.

I am ready to admit with Prof. Church, that the traditional opinions of practical men have often required correction from scientific investigation, but upon the present occasion, so far as I have been able to judge, the ironmaker and the chemist agree in the relative value of hard and soft coke.

I. LOWTHIAN BELL

PAPUAN HERPETOLOGY¹

IN this memoir, which forms a portion of the thirteenth volume of the *Annals* of the Civic Museum of Genoa, we have by far the best account of the herpetology of

¹ "Catalogo dei Rettili e dei Batraci raccolti da O. Beccari, L. M. D'Albertis e A. A. Brujini, nella sotto-regione Austro-malese." Per W. Peters e G. Doria. *Ann. del Mus. Civico*, Genoa, vol. xiii., 1878.