JOSEPH BLACK M.D.

WITH SPECIAL REFERENCE TO
HIS INFLUENCE ON MEDICINE.

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Wellesse Gold Medal in the History of Medicine 1922

T. Ferguson,
1922.
The University New Buildings
Edinburgh 4th July, 1922.

Dr. J. D. Comrie,
25, Manor Place,
EDINBURGH.

Dear Sir,

Essays, which have been lodged for the Wellcome Medals, are sent you herewith for examination and report. Professor Barger will also act as an Examiner.

Yours faithfully,

[Signature]

Dean.
"Chemical science has traveled a long road in the period between "fixed air" and argon. But the great investigator and discoverer are still the same, and the mantle so honourably worn by Ramsey was none other than the mantle of the great and genial Joseph Black.

— Y. Y. Deman.

Black's was a many-sided genius, and the merit of his work as a pioneer in medicine is apt to be overlooked by virtue of his celebrated contributions to chemical science. But it is significant that several of his results were obtained while he was attempting to solve medical problems and many of his discoveries have important medical applications.

To the Chemist, Black's fame rests mainly on three pillars—his work on alkalies, and his discoveries of fixed air and laterit haust. "De humori aerei et magnesia alba" was early recognized as a classic, and is likely to remain so. His experiments thus described first made clear the relation between caustic and mild alkalies, that is, between the alkali oxides and the alkali carbonates. These relations were not understood by the early chemists. They believed the 'mild alkalies' and 'mild earths' to be elementary substances; that the causticity of lime was due to the union of 'fire matter' (phlogiston) with the element that
with the conversion of mild alkali into caustic alkali and the simultaneous regeneration of chalk by boiling the former with caustic limes, was due simply to the transfer of the 'fire matter' from the lime to the mild alkali. Otherwise expressed,

\[
\text{Quicklime} = \text{Chalk} + \text{Fire matter}
\]

Black found his hypothesis to be untenable. He demonstrated experimentally that chalk after ignition neutralised the same quantity of acid as before ignition, but the calcined chalk dissolved in the acid without effervescence, whereas the original chalk lost a gas, which he called 'fire air.' The parts formed by the action of acids on calcined and uncalcined lime are identical in every respect, and the same amount of gas is expired from chalk whether the chalk be calcined or digested in acids. Further, by weighing the chalk before and after calcination, Black found a loss, not a gain, in weight. Thus:

<table>
<thead>
<tr>
<th>Ordinary Chalk</th>
<th>120 grains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quicklime</td>
<td>65</td>
</tr>
<tr>
<td>Loss in weight</td>
<td>52</td>
</tr>
</tbody>
</table>

"Hence," added Black, "we may safely assume that the volatile matter lost during the calcination is mostly air, and hence calcined lime does no emit air or make any effervescence when mixed with acids." Again lime becomes caustic owing to the loss of fire air. Consequently, Black proved

\[
\text{Chalk} = \text{Quicklime} + \text{Fire air}
\]

Therefore, Quicklime is simpler than chalk or limestone.

On boiling the 68 grains of quicklime obtained in the experiment with hot ashes, Black finally obtained 118 grains of a
white powder "similar in every trial" to ordinary chalk. At 118 grains of chalk corresponded with the 120 grains originally taken, within the limit of experimental error. The resulting caustic potash no longer effervesced with acids, whereas the regenerated chalk did. Hence Black concluded that the pot ash was made caustic by the transfer of the gas contained in pot ash to the caustic lime. Black thus demonstrated the modern view of the changes which attend the transformation of a milk into a caustic alkali, and proved that these changes are similar to those which occur during the conversion of a milk earth into a quicklime. Black's experiments also made clear the relations between the "milk alkali" (alkali carbonate), "caustic alkali" (alkali hydrate), "milk earths" (carbonates of alkaline earth) and the "quicklime" (oxide of the alkaline earths).

This work on alkali, Black began with the hope of discovering a new sort of lime and lime water which might possibly be a more powerful solvent of renal calculi than that commonly used. In this, of course, he was doomed to disappointment; his own conclusions on the subject are instructive, and somewhat suggestive of a later-day attitude to powerful antiseptics:— "The aqua alkalina airdara is certainly an excellent medicine in calculous cases as a solvent, but as a most effectual palliation, ascertained by experience. I know no solvent to be relied on. Caustic alkali is very powerful, but that it may not act on the bladder daily it must be so employed that its action on the calculi is very slow, and the patient is fattened and tired. The aera-
alkali was continued aqueous)

That Black recognised the value of alkalis in counteracting gastric acidity is reflected in his decision to prepare his Phœnix with some notes, as short as possible, on the acid humours derived from food, for which alone magnesium serves as a remedy.

As has been shown, the quest for a urinary solvent resulted in the discovery of fixed air. Black also noted that this substance, given off by guinea-pigs and alkalis, is also present in expired air, and is physiologically in respirable, although not necessarily toxic. He emphasised this non-toxicity, and advocated the use of fixed air in gastric conditions, in consumption, in malignant fevers, and in fevers generally: it mitigates pain, promotes a good digestion of the food, and restores the putrid discharges of the fluids.

Black's third great contribution to science was his discovery of Latent Heat in 1762. "I imagined," he said, "that during the boiling of fluids heat is absorbed by the water, and enters into the composition of the produced water. And, so the sensible effect of the heat in this last case consists not in warming the surrounding bodies, but in converting the water into vapour. In both cases, considered as the cause of warmth, we do not perceive its presence: it is concealed or latent, and I gave it the name of "Latent Heat."

Perhaps the most obvious result of this discovery was the evolution of the steam engine, but it had also far-reaching medical
effort: it revolutionised Mansi whole outlook on temperature, and had a profound influence on contemporary opinion. An interesting side-issue of Black’s work on latent heat was his advocacy of frigoric mixtures. He pointed out that an aqueous solution containing sal ammonium, saltpetre, and salitre salts will reduce a temperature by 48°F: his works in this sphere made possible the introduction of refrigeration, and directed attention to a method of winter irrigation.

Black was one of the earliest adherents in Britain to the anti-phlogistic theory of combustion advanced by Lavoisier. Prior to this time, during the greater part of the 18th century, the accepted view was the phlogiston hypothesis, which held that on calcination, metals lose a hypothetical substance called provitroor Stahl (1723), taught that in the act of combustion, phlogiston, an intrinsic constituent of combustible bodies, was set at liberty. Oxidation was said to be due to the escape of phlogiston: reduction, to the absorption of phlogiston. When a metallic oxide was heated with a substance rich in phlogiston, e.g., charcoal, a reducing agent generally, the charcoal supplied the calx or metallic oxide with phlogiston, and reproduced a compound of phlogiston with the metallic oxide which was the metal itself. Metals even then supposed to be compounds of phlogiston and their oxides (oxides). If phlogiston escaped, the metallic oxide remained. The idea can be symbolised

\[
\text{metal} = \text{phlogiston} + \text{metal calx (oxide)}
\]

When it was shown that the metallic oxides were heavier than the
corresponding metal (e.g., Reay's experiment), it was assumed that phlogiston was lighter than air, so that the metal was buoyed up, as to speak, by the associated phlogiston.

Lavoisier's conclusive proof (1744) that the increase in weight which occurs during combustion is equal to the weight of oxygen absorbed from the air, and his crucial demonstration that combustion is a process of absorption and increase in weight which cannot be explained by a supposed loss of substance, soon banished the phlogiston hypothesis from the domain of science. In the words of Voltaire: phlogiston died as an old King—once infinitely dominant, somewhat tyrannical, and always just: now defaced, received, utterly smiled, forgotten by all.

The phlogiston theory is sometimes held up to ridicule, but it must be borne in mind that the hypothesis was accepted by nearly all the leading chemists in the earlier part of the 18th century, when it appeared to be as firmly fixed among the root principles of chemistry as are the Kinetic Theory today. The phlogiston theory represented the most perfect generalization known to the best intellects of its day. It is inconceivable that men like Black and Priestley would conspire what they considered to be an inconsistent doctrine: phlogiston was regarded not as a temporary hypothesis, but as a permanent acquisition, an enduring conquest of truth.

Thus can be little doubt, then, that in the first instance, Black accepted the phlogiston theory, pretty much as did his contemporaries, but he was one of the earliest
conver to Lavater’s views. “When we examine further,” he says in his lectures, “we find this part of the subject very obscure and unsatisfactory, and the opinions very unsettled.” Indeed, he seems to have been one of the earliest doubters, for a little further on he remarks, after describing the new view, “This is the opinion I had of it formerly, before the existence of a phlogiston, or principle of inflammability, began to be doubted; he suggests that the antiphlogistic theory is a natural outcome of his doctrine of latent heat.

The whole question is of great medical interest, as bearing directly on inflammation, respiration, and general metabolism. That its importance was early recognised is evidenced by the application of the term “antiphlogistic” to the method of treating pneumonia by vigorous bleeding, a practice which held the field for some time till superseded by the less drastic ‘restorative method’ sponsored by Hughes Bennett.

Before passing to the consideration of Black as a clinician, we may consider briefly his studies as an experimenter and as a teacher.

Black was essentially an experimenter: he first obtained his facts by work carefully planned and skilfully executed: then to these facts he applied his keen, sane, deductive instinct, and the results — the exposition of the alkalies, the anaemic of latent heat and forced air — fully justified his methods. His work entailed the use of the balance; and
with the introduction of quantitative methods begins a new era in scientific progress.

His Lectures, too, are models of their kind, and permeated throughout his lecture Chemistry are numerous references to points of medical interest which could not fail to stir up his audience. His explanation of such subjects as the distribution of heat saw as clear as ever were given of any subject, and might serve as a pattern to our modern laconic writers. His teaching was characterised by a splendid purity, and a marked impartiality: he did not hesitate to acknowledge his indebtedness to others, whether his contemporaries or his predecessors.

Black, then, was a Chemist pre-eminent, but he was also a Medical man, and Physician to His Majesty for Scotland. His medical practice in Edinburgh was not an extensive one, yet he appears never to have dropped it, and from time to time he received letters on medical subjects from his numerous pupils. What then, were his medical ideals? What were his characteristics as a Clinician?

The dominant note here was again his shrewdness: some idea of his nature can be gleaned from a study of his teaching on the substances of medical importance—camphor, antimony, and tin.

After dealing in his Lectures with the physical qualities of camphor, he proceeds: “As it is distinguished from the other oils of the
volatile spirit by their chemical qualities, it is remarkably distinguished
from them also by its medicinal qualities, being much less
heating and stimulating than the essential oils, though at the
same time it has great powers as an anti-spasmodic, an
anti-septic and a diaphoretic. But we must not give it in
such large doses as are paid to be given in England –
hence peoples as our are not safe, except perhaps in mania.
Applied externally it is very powerful in displacing rheumatic
pains.

In these few lines, Black continues to give a very fair summary
of our present day knowledge of the therapeutic of Camphor.
Again, in discussing iAntimony he says: "Walthorp
testifies that it is emetic, and purgative, and diaphoretic.
Wilson’s Antimonium Carbamicum is probably of the same
nature. Wilson calls it an imperfect purge, and says that
he knew thin fortes cured by it. They were probably some
cutaneous disease that he mistook for fever." — which shows,
at least, that he had mastered the habit of citing
clinical evidence.

Perhaps the best instance of the application of his keen
analytical faculty to Medicine is to be found in his description
of the use of tin as an antihelmintic. His query as to the
possibility of this action being due to lead or arsenic impurities
reveals another phase of Black’s medical activity — he was, as
might have been expected, keenly interested in the preparation
and purification of drugs.

This chemical genius, too, frequently touched the fringe of public health. In 1794 he made reports on water from the Well of Leith, and also on water from Saltspring Craggs; the details of his report are interesting. "No. 1 was clear to the eye. In the taste, it was sweet and good water. In dissolving soap, it was rather softer than Edinburgh pip water. 4000 grains of it left on every only 3/4 grain solid matter, which was saline and earthy."

As early as 1740, Black was asked to examine, and actually reported on, the water supply of New Castle upon Tyne, obtained from a spring at Combe.
of a great Master upon an exceptional Pupil: it is not improbable that the extreme value attached by Bullen to the advancement of chemistry as applied to medicine was in great measure responsible for the investigation of the nature of magnesia alba and quicklime undertaken by Black, which led in the hands of his pupil to the elucidation of the relationships of the mild to the caustic alkalies.

Black, in turn, influenced Bullen, whose experiments on evaporating fluids were suggested by a remark made by his pupil. The friendship which developed between these two men was of the closest and was maintained by families and intimate correspondence upon chemical and medical subjects after Black had proceeded to Edinburgh in 1750 to continue his studies.

Of the more immediate results of Black's work, two especially are worthy of mention — his influence on Rutherford's work on animal respiration, and on Laotius's theory of combustion.

Rutherford's thesis was entitled De aere fixo et mephitico. In it he deals first at some length with Black's fixed air, which he uniformly calls mephitic air, but, so far as this air is concerned, he does not attribute much that is not already known. He then proceeds to discuss the effects upon a confined portion of air, of animal respiration, followed by the removal of the mephitic produced. He states that by the respiration of animals wholesome and good air not only becomes mephitic, but it also suffers another singular change. For after all the mephitic air has been separated and removed from it by means of caustic lye,
still what remains does not become in any way more wholesome. for although it produces no precipitate in lime water, it extinguishes both flame and life no less than before."

By his influence a Larrocin this can be no doubt: in his Lectures Black himself says - "The two very different combinations of heat which I have discovered in which it produces fluidity and vapours encourage me to presume that there was another combination which produced a permanently elastic fluid, no decompressible, like a liquid, by the touch of a solid body, and the different capacities for heat having been already discovered, it appears no difficulty to account for the vast quantity set free in combustion. This new theory, therefore, is founded on the doctrine of Latent Heat, and is indeed an extension of it." (Vol I. p 239).

Such was the influence of Joseph Black. His work, and its diverse medical applications were of vast importance, but of even greater moment was the recognition of his guiding principles, his perspicuous practice, his quantitative experimental methods, the very fact of the application of his clear intuitive intellect to the solution of medical problems which only arose with the dawn of the new science. This was a critical faculty: he emphasised the advice of René Descartes - "Give unqualified assent to no proposition which is not presented to the mind so clearly that there is no room for doubt." As Aristotle would have said, we do not need to cultivate the art of arguing, but rather the art of doubting well.