Blood and Respiration

An Historic Documentary, 1978.

Scientific reconstruction by Henry Barcroft
with Peter Goodford, Frank Norrington and colleagues from The Wellcome Research Laboratories.

Opening Commentary: Edwin Potter
Stills Photographer: Laurie Hole
Music: Frank Norrington
Technical Adviser: Alan Masters
Lip Reader: Sheila Savill

Colour
Duration: 00:13:04:13

00:00:00:00

<Opening titles>

<Intertitle>

> **An early film on the study of the blood-oxygen equilibrium, originally made by Joseph Barcroft**

<Potter narrates over film, opening shot shows 1976 paper of The Physiological Society>

There was a tantalising glimpse of the past at The Physiological Society's 1976 centenary meeting when an early film was presented showing Professor, later to be Sir, Joseph Barcroft demonstrating his method of determining the dissociation curve of the haemoglobin oxygen system. This was an experiment he carried out many times in the mountains of Peru and Tenerife when, in the early part of this century, he

was investigating the effect high altitude had on the blood – work which was to lead to the publication of his well-known text book, The Respiratory Function Of The Blood.

The film which was found by chance in an obscure corner of Cambridge was made by Sir Joseph in his own laboratories in the mid 1930s. It has now been examined and compared with his published papers by Sir Joseph's son, Professor Henry Barcroft, and by Dr Peter Goodford, Dr Frank Norrington and others in the biophysics and biochemistry department of the Wellcome Research Laboratories. The commentary, which has been added, is an attempt to clarify the film for modern audiences and interpret the original scientific experiment as faithfully as possible. It is spoken by Professor Henry Barcroft.

<Professor Henry Barcroft narrates over film showing Sir Joseph Barcroft in his laboratory in the 1930s, demonstrating equipment and conducting his experiment to investigate the dissociation curve of the haemoglobin oxygen system>

When my father led scientific expeditions to remote parts of the world, he had to develop robust but lightweight equipment which he could take anywhere and which could produce a full oxygenation dissociation curve from a small amount of blood. The admiring onlooker on the right is Dr Adrian later to become Lord Adrian.

On the racks, this side, he would normally mount eight Barcroft differential manometers, although for this demonstration, he's using only one. The Barcroft differential manometer was a forerunner of the Warburg manometer. Since both sides were sealed, it had the advantage of being automatically compensated for temperature variation and was unaffected by changes in barometric pressure. It was therefore ideal for use in the field. However, because it worked neither at constant pressure nor constant volume, the mathematics were somewhat complicated and perhaps this was the reason why it was not more widely adopted.

This tubular vessel is a tonometer which can be used to equilibrate a small blood sample with the gas mixture inside. A funnel serves as a convenient mercury reservoir, although the health authorities might have something to say about it today <*Sir Joseph Barcroft seen with hand dipped in reservoir of mercury*>.

Now he has a tonometer filled with nitrogen <*fixes it in place in clamp stand*>. His test sample is probably blood which he will already have defibrinated by whipping with a feather or a wire brush. Alternatively, it might be a solution of haemoglobin; we can't be sure. Either way it makes little difference to the demonstration.

00:06:21:00

To make the gas mixture required, he must introduce oxygen in the form of air into the tonometer. At the moment, he is only measuring the volume of air approximately; he will analyse it later.

Now for his blood sample. Notice how careful he is to preserve a drop of mercury in the bottom; this will enable him to purge air from the tap when he comes to remove the sample for analysis. Now before continuing with the experiment proper, my father is going to digress a little and show us the effect temperature has on the oxygen haemoglobin equilibrium. Blood in contact with air is fully oxygenated and bright red as the reference sample at the top shows. The fact that they are both the colour of arterial blood indicates that even with the small volume of air present in the test tonometer, the solution is largely saturated with oxygen in the cold.

<*Hot water poured into water bath*> But now it is a different story: at a higher temperature, the reference sample is still bright red, but the test sample has turned a dark red of venous blood. In other words, heat has driven off the oxygen by altering the shape of the dissociation curve. And this effect is reversible. <*Test and reference sample vessels placed in iced water and colour is restored to that of arterial blood*>

But now back to the main experiment. Although you can't see it, the little tube contains two chambers. Into one of these, he can introduce potassium ferrocyanide

in such a way that it only comes into contact with the blood after the monometer has been sealed. The ferrocyanide drives off all the bound oxygen, causing a deflection on his manometer, and the experiment was ingeniously designed to be independent of the quantity of blood present in the tube. So, now he can calculate the degree of saturation of the blood with oxygen. He wants to plot this degree of saturation against the partial pressure of oxygen in the gas above, and a conventional Haldane gas analyser forms part of his travelling apparatus. See how he's inverted his tonometer so as to draw off the gas phase instead of the liquid.

So, now he can start to plot his dissociation curve. The vertical axis is the percentage saturation of the haemoglobin in the sample with oxygen and this he plots against the oxygen partial pressure. With eight manometers and eight tonometers, each containing a different amount of oxygen, he could and frequently did plot a full dissociation curve: the curve which is the key to understanding the respiratory function of the blood.

This old film then gives us just a glimpse of how Joseph Barcroft conducted his pioneering research both in his laboratory and in expeditions which he led to many remote and inhospitable corners of the world.

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THE END