A. V. Hill's photograph album

Hill's papers in the Archives at Churchill College Cambridge are filed in dozens of manila envelopes. Among them is an album of photographs from the 1920s, mostly of fellow scientists. His grandchildren recall that he was a keen photographer with a home darkroom. Some of his photographs are eye-catching. (He was also good at drawing.)

Obviously he did not take Fig. 1, but it may have been taken with his camera. It shows Hill and Otto Meyerhof. They shared the Nobel Prize in 1922 for their discoveries on muscle (Katz, 1978). Hill used thermocouples to measure the heat released during contraction and recovery. Meyerhof measured the rise in lactic acid during tetanus and its fall during recovery, when part was oxidized and the rest rebuilt into carbohydrates. They are at the German border on their way to Stockholm for the Physiological Congress of 1926. Their costumes suggest that they may have been travelling in an open automobile. Hill was keen on cars, motorcycles and power boats.

For the first 16 months of World War I Hill served as an infantry officer. Then he was transferred to the Ministry of Munitions to work on anti-aircraft gunnery, because, as he put it, he "had shown signs of the unpleasant habit of inventing things" (Hill 1918). He devised a method for measuring the position of flying objects with two widely separated mirrors. Conscription forced him to recruit over- or under-age, mathematically talented collaborators. Eventually there were more than 100; they were dubbed "Hill's Brigands". With the mirrors they located shell bursts from test firings. First trained in maths, Hill became known in physiology by fitting equations to data on the contraction of the frog rectus abdominis in response to different concentrations of nicotine, based on nicotine binding to a receptor substance in the muscle, and to

Figure 1. A. V. Hill (1886–1977) is on the left; Otto Meyerhof (1884–1951) is on the right. (All photographs are from the Churchill Archives Centre, A.V. Hill Papers, AVHL II 5/119.)

Figure 2. William Hartree (1870–1943) dissecting a frog muscle in the Cambridge Physiological Laboratory. Note his cylindrical slide rule for high-precision calculations. Some of his maths was to correct their thermocouple measurements for the delays in their recording apparatus.

Figure 3. Ernest Starling (1866–1927) in his laboratory at UCL with two assistants. His gaunt, cachectic appearance shows that his health was failing; in 1920 he had been operated on for a colon cancer.

data on the dissociation of O_2 from haemoglobin, introducing the idea that it has several binding sites. The Brigands pulled off the greater challenge of fitting the positions of shell bursts with equations that accurately describe the path of projectiles hurtling skywards, including the effects of wind, temperature and shell velocity. They also developed apparatus to locate aircraft by sound. The Brigands took their science into the field – they pioneered operations research.

Hill led the group intellectually and also made science glorious fun. One of his recruits was William Hartree (Fig. 2), a retired engineer, who so enjoyed working with Hill that after the war he stayed on as a volunteer. Together they published 36 papers on muscle.

After the war, Hill became professor at Manchester, where he studied human exercise, coining the term ‘oxygen debt’. He was a keen runner. Then he was brought to UCL to replace Ernest Starling (Fig. 3), who became a Foulerton Royal Society research professor (Henderson, 2005). Every physiologist can list Starling’s great ideas that emerged from brilliant experiments. On a memorable day in 1902 he and his collaborator and brother-in-law, William Bayliss (1860–1924) were working on pancreatic secretion. It was known that injecting dilute HCl into the duodenum stimulated secretion, even when the vagus was cut. Their hypothesis was that the reflex operated through an abdominal nerve network. Therefore they tied off a segment of duodenum and painstakingly severed every nerve running to it. Dilute HCl injected into intact duodenum elicited secretion. So did injection into the isolated, denervated segment. Quick as a flash, Starling announced that there must be a chemical messenger. He snipped out a piece of the isolated segment and ground it in a mortar with sand and some of the HCl. Injecting the filtered solution into the jugular evoked secretion; HCl alone did not. A few weeks later they proposed that such chemical messengers should be called hormones.

Figure 4. Ivan Pavlov (1849–1936).

The doyen of gastrointestinal physiology was Ivan Pavlov (Fig. 4). He measured the volume and composition of digestive secretions by diverting output to an opening on the dog’s body surface; he would study these animals for years. He concluded that these secretions were regulated by nerve reflexes.

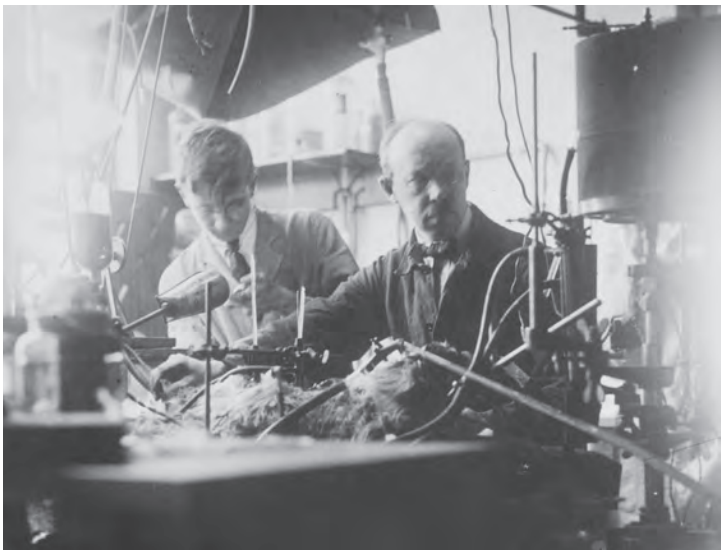

Figure 5. Gleb Anrep (1891–1955) on the right, working at UCL during the 1920s.

In his Nobel Lecture in 1904 he did not mention hormones. He had tried to repeat the UCL experiment, but his intestinal extracts did not evoke secretion. On the other hand, he had reported that stimulating the vagus elicits copious secretion from the pancreas; at UCL vagal stimulation elicited scanty secretion at best.

Pavlov came to England in 1912 for the celebration of the 250th anniversary of the Royal Society, and also received an honorary degree from Cambridge. Instigated by Hill, when Pavlov sat after receiving his diploma the students lowered from the ceiling into his lap a toy dog kitted out with glass and rubber tubing. Pavlov prized this salute from the younger generation and it is now displayed in a St Petersburg museum (Henderson, 2005).

The conflicts in results were resolved in 1912 when Pavlov sent a medical student, Gleb Anrep (Fig. 5), to UCL during the long vacation (Gaddum, 1956). They showed him how to prepare the hormone. They also showed him that Pavlov's protocol destroyed the secretin by over-neutralizing the extract. In his turn, Anrep tried to show them that vagal stimulation elicited pancreatic secretion. His first two tries failed. He discovered that UCL dogs were given morphine before anaesthesia. It was not used in Russia. Without morphine, vagal stimulation worked splendidly. Anrep visited thrice in the next years, publishing his first paper in *The Journal of Physiology*. His last visit was cut short by the outbreak of war in 1914. He returned to finish medical school and then served in the Russian Army and the White Army. When the counterrevolution was defeated he emigrated to Britain, working at UCL and Cambridge. He translated Pavlov's lectures on conditioned reflexes, published in 1927, for which the Royal Society paid him £100.

Anrep's father was a pharmacologist who, at the Tsar's command, established the first medical school for women in Russia. Female physicians were needed because

Figure 6. August Krogh (1874–1949).

Moslem women would not be treated by males. This may have influenced his son's undertaking a professorship at the University of Cairo in 1931, where he strove to build a department like Pavlov's and Starling's. He worked on histamine and set up the first human heart–lung preparations. He was sacked following the nationalist revolution in 1952.

August Krogh (Fig. 6) shared Hill's interest in exercise physiology (Henriksen, 2000). He was awarded the Nobel Prize in 1920 for proving that capillaries open up when muscles contract, which he showed by injecting India ink into the circulation and then fixing and sectioning resting and contracting muscles. The University of Copenhagen established a Department of Zoophysiology for Krogh and his wife Marie, also a talented experimenter. They showed that oxygen diffuses from the alveolus into the blood. Previously, J. S. Haldane, at Oxford, and J. Barcroft, at Cambridge, had argued that oxygen must be transported actively. At the end of his life Krogh was investigating active transport of ions into marine organisms. He was curious about everything. He worked on topics as diverse as the diet of Eskimos, the physiology of the blue whale, and how insects prepare for flight.

In 1926 Hill also became a Foulerton professor, which freed time for research, but he was not permitted to opt out from UCL committees, where he did such good service. (Starling had been allowed to escape, and was missed.) The wise hand steering the biological side of the Royal Society at that time was William Bate Hardy (Fig. 7). He started as a zoologist, taught histology to the Cambridge physiology students, studied the effects of radiation on cells (burning himself with radium carried in his vest pocket), and then moved on

Figure 7. William Bate Hardy (1864–1933). Labelled in the album as 'W. B. Hardy photographed by A. V. H. at University College.'

to colloids, lubricants, and finally marine biology. If one follows the steps it was a logical progression. As a scientific statesman he was a model for Hill, who in turn became deeply involved in public issues, even serving a term as an MP. Both had to cope with the irrationality of politics. For example, in 1917 Hardy had to cope with a government food controller who instructed the public not to eat bread and meat at the same sitting because it doubled the work of digestion.

Otto Loewi (Fig. 8), professor of Pharmacology in Graz, Austria, took a prominent role in the 1926 Physiology Congress, where he was invited to demonstrate his great experiment – famously its protocol came to him in a dream. He stimulated the frog vagus for a few minutes until the isolated heart slowed and contracted with less force. Then he transferred the Ringer solution from this heart to a second, which also slowed and beat less strongly, showing that the vagus released a chemical. This experiment is tricky to replicate. Usually released acetylcholine is swiftly hydrolyzed by acetylcholine-esterase. He was lucky. His first tries worked because he used winter frogs, some of whom have a low titre of the esterase. Those who tried unsuccessfully to replicate his experiment were naturally dubious. After he identified the transmitter he solved the problem by inhibiting the enzyme with neostigmine, but naturally was apprehensive – we all know that demonstrations are dicey. In Stockholm he was successful 18 times with the same two frog hearts. (Loewi, 1960)

The photograph in Fig. 9 of L. J. Henderson must have been Hill's favourite: there are two different prints in the album. A Harvard professor, it was taken at his camp at Morgan Center Vermont. Every physiologist knows the Henderson–Hasselbalch equation, a product of his work on the physical chemistry of blood. Like Hill he was a champion of biophysics. He was celebrated for his writings on how the earth's chemistry favoured life. He also strongly supported and taught an esoteric theory of sociology.

The Nazis threw out hundreds of intellectuals in the 1930s – an astonishingly generous donation to their opponents. Hill was active in finding places for scientific castaways; for example, bringing Bernard Katz to UCL. Meyerhof ended his career at the University of Pennsylvania and Loewi at NYU. In 1951 they had an embarrassing encounter on a train going from New York City to New Haven, Connecticut. Both were on their way to Yale to receive honorary degrees, but were pledged to

Figure 8. Otto Loewi. He shared the Nobel Prize for 1936 with his friend Sir Henry Dale for their work on chemical transmission. They first met in Starling's lab at UCL in 1902.

Figure 9. Lawrence J. Henderson (1878–1942). Under the second print of this photograph in his album Hill wrote, 'And the spirit of God moved up the face of the waters.'

secrecy, so during the journey they meticulously, but with obvious difficulty, evaded discussion of why they were on the train.

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