BIOGRAPHICAL MEMOIRS

Edward Hindle, 1886-1973

P.C.C. Garnham, F. R. S.


Email alerting service
Receive free email alerts when new articles cite this article - sign up in the box at the top right-hand corner of the article or click here.
EDWARD HINDLE
1886–1973
Elected F.R.S. 1942

BY P. C. C. GARNHAM, F.R.S.

Edward Hindle was born in Sheffield on 21 March 1886, the son of Edward James Hindle and of Sarah Elizabeth (née Dewar). He was the eldest of a family of six children, consisting of two sons and four daughters. The Hindles (or Hindley as the name was earlier spelt) came originally from Lancashire, but Edward’s grandfather, James, went south to Wirksworth in Derbyshire, where he took an active part in local affairs. The son, Edward James Hindle, was trained as an engineer, but he was more interested in music; he became an organist and composed hymns, and was a lay reader in the local church. Edward Hindle’s mother came of an Edinburgh family; her grandfather was an amateur astronomer and was the only member of Hindle’s immediate ancestors to have any interest in science.

EARLY YEARS

Hindle was mainly educated at home by his mother, who was a qualified teacher and who early recognized his interest in natural science. She encouraged him in this subject, while his father inspired him with a love of music. Later he attended classes at the Bradford Technical College and in 1903, he was awarded a national scholarship in biology at the Royal College of Science, South Kensington.

Hindle spent the next four years in London, taking his Associateship in Zoology in 1906 and at the same time working at King’s College with Professor A. Dendy, F.R.S., on a collection of holothurians from New Zealand. In 1906 his family left England for California. After a year as a research assistant at the Liverpool School of Tropical Medicine, Edward rejoined them there in 1908. He first spent six months at the Marine Biological Station of La Jolla and then entered the University of Berkeley where he obtained the Ph.D. in 1910.

On his return to England in 1910 he went up to Cambridge (Magdalene College) as an undergraduate and took his degree in the Natural Science Tripos (B.A. 1912; M.A. 1917). He became Sc.D. in 1926. He spent the summer of 1911 at the Institut Pasteur in Paris, studying with Professor F. Mesnil and
Professor E. Marchoux. With the latter, he carried out experiments on the transmission of fowl pest with *Argas persicus*.

Probably Hindle had no true ‘mon maitre’, but perhaps the nearest was Professor G. H. F. Nuttall, F.R.S., who established him in his career in tropical medicine. It is difficult to specify his exact subject. The entomologists claim him as one of themselves and the President of the Royal Entomological Society (Professor A. D. Lees, F.R.S.) in his obituary address to the Royal Entomological Society (of which Hindle had been a member for 37 years) referred to his many important discoveries in the field of medical entomology. Yet his greatest discovery was in virology: a prophylactic vaccine against yellow fever; but perhaps he is best known for his introduction of the golden hamster into the home and laboratory. Professor Evens in a memorial address to the Académie Royale des Sciences d’Outre Mer de Belgique reversed the order of these achievements in the following words, ‘Il a droit à la reconnaissance de tous les biologistes travaillant dans les laboratoires, parce qu’il leur a fourni le hamster comme animal expérimental, et il a droit à la reconnaissance de toute l’humanité pour ses travaux sur la fièvre jaune’.

Hindle thought of himself as a biologist interested in the arthropod transmission of disease. His life coincided with the ‘Rise and fall of research on the arthropod transmission of disease’. He was born in the year 1886, about the time when Sir Patrick Manson, F.R.S., was working on the transmission of the first helminths (filarial worms) by mosquitoes, and Theobald Smith, For. Mem. R.S., on that of the first protozoa (piroplasms) by ticks. And he died when the sun had begun to set on the possibility of making new discoveries, for it seems that few life cycles of parasites in arthropods now remain to be discovered.

Nuttall introduced his pupil and collaborator to the ‘heteroeccistic approach’ —the two-host system which forms the two pillars of parasitology. An attack on either pillar can lead to the collapse of the parasitic infection. Nuttall asked Hindle (in 1913) to contribute to the Cambridge Public Health Series of books, of which the first had dealt with ‘Flies in relation to disease: non blood-sucking flies’ by G. S. Graham-Smith, F.R.S., and the second was to be on the blood-sucking flies. Hindle complied. It is remarkable how much had been discovered by 1913, and yet there were many misconceptions at that time, including subjects which were greatly to be influenced by Hindle’s own work. Referring to yellow fever, he stated in this book that ‘it is literally possible within a few months to remove this most deadly disease from the list of human ailments’ (by measures directed against the mosquito, *Aedes aegypti*). Unfortunately this is completely untrue, owing to the presence in the background of animal reservoirs and sylvatic vectors. He was slightly less optimistic about malaria control and identified what has proved to be the main obstacle to success: the inability of some countries to adopt measures for the eradication of the disease. The book was written before the discovery of the rôle of *Phlebotomus* in the transmission of *Leishmania*, research in which Hindle was later to play important part; it was too early also for the inclusion of the insect host's
of several important filarial diseases such as onchocerciasis, or of avian infections such as those caused by *Leucocytozoon*, and of course at that time the only known invertebrate vectors of virus diseases were *Aedes aegypti* (yellow fever) and *Phlebotomus* spp. (sandfly fever). These and many other lacunae doubtless stimulated Hindle to a study of the general problem which was to form the chief subject of his researches.

**Career**

Hindle had three main interests in the course of his long life: (1) active service on behalf of his country; (2) administration, including the formation of new or the transformation of old societies, clubs and departments and (3) research. He was to find that none of these was compatible with the others, and comments on the effect of the first two on his scientific output will be found elsewhere (pp. 222 and 224) in this memoir.

Perhaps Hindle’s keen interest in animals *qua* animals should have been added to this list as a fourth item; but animals formed an integral part of his research and to the various organizations with which he was concerned. He was keen on natural history from early childhood and began collecting specimens from the age of seven. Then in his teens he was fortunate in meeting at Bradford Technical College, William West, the distinguished algologist who helped him to make more scientific collections of animals and plants. Much later in life he became intimately associated with the Glasgow and London Zoological Gardens and with various societies connected with animal welfare.

**Military service**

He enrolled in the Territorials in 1913 in Cambridge and on the outbreak of war in the following year immediately joined up. He was gazetted on 1 October 1914 to the Royal Engineers as a second lieutenant. He served as a signal officer first in France and then in Palestine. During the winter of 1917–18 he returned to England to take command of the newly formed Signal Service Training Unit for officers. He went back to Palestine in April 1918 and served as Signal Officer, first in the 60th Division and then in the Indian Army. He was demobilized in Egypt in 1919.

When the European situation became threatening once again in 1938, Hindle was in the Regius Chair of Zoology in Glasgow and he took an active part in the Officers’ Training Corps of the University. He became Lt.-Colonel (General List) and Commanding Officer of the whole Corps, comprising infantry, artillery, medical and signals units. He was also appointed Secretary of the Reception Unit for recruitment of officers in the West of Scotland. Later in World War II he commanded the 14th Battalion, City of Glasgow, Home Guard.

Several people have suggested that Hindle could have made a brilliant career in the Army; he himself favoured music as the alternative to science.
Apart from the work entailed by his professional appointments, Hindle took on a large number of outside commitments of both professional and non-professional interest. These are listed in table 1.

**Table 1. Honorary posts held by Edward Hindle**

<table>
<thead>
<tr>
<th>Association or Society</th>
<th>Post held</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scottish Marine Biological Association, Millport</td>
<td>Chairman</td>
<td>1935–43</td>
</tr>
<tr>
<td>Zoological Society, Glasgow and West of Scotland</td>
<td>Founder and First President</td>
<td>1936–44</td>
</tr>
<tr>
<td>Royal Philosophical Society, Glasgow</td>
<td>President</td>
<td>1943–44</td>
</tr>
<tr>
<td>Royal Society of Edinburgh</td>
<td>Vice-President</td>
<td>1943–46</td>
</tr>
<tr>
<td>Universities’ Federation for Animal Welfare</td>
<td>President</td>
<td>1944–73</td>
</tr>
<tr>
<td>British Association for the Advancement of Science</td>
<td>General Secretary</td>
<td>1946–51</td>
</tr>
<tr>
<td>British Association for the Advancement of Science (Zoology)</td>
<td>President</td>
<td>1947</td>
</tr>
<tr>
<td>International Wildfowl Research Bureau</td>
<td>Founder and First Director</td>
<td>1947</td>
</tr>
<tr>
<td>Institute of Biology</td>
<td>Founder and First President</td>
<td>1951–53</td>
</tr>
<tr>
<td>Royal Geographical Society</td>
<td>Hon. Secretary</td>
<td>1951–53</td>
</tr>
<tr>
<td>International Union Biological Sciences (Zoology)</td>
<td>President</td>
<td>1953</td>
</tr>
<tr>
<td>Royal Geographical Society</td>
<td>Hon. Vice-President</td>
<td>1962</td>
</tr>
</tbody>
</table>

Hindle was a good teacher and on his arrival in Glasgow he created an upheaval in the traditional zoology courses, introducing novel ideas with a strongly practical bias and orientated towards entomology. Living lice were provided for the students and mosquito larvae were collected from swamps near the city. Some of the older systematists on the staff disliked this approach and left, but his curriculum particularly appealed to students who were lining up for a career in medical entomology. Several of them became prominent figures in later life (Professor D. B. Bertram, Professor W. H. R. Lumsden and Dr R. C. Muirhead-Thomson). Other members of his staff or students became professors in Chairs of Zoology or Biology in England (e.g. G. E. Foxon at Guy’s, E. R. Trueman at Manchester and L. H. Finlayson at Birmingham) while Guido Pontecorvo, F.R.S., later became Professor of Genetics in Glasgow and O. E. Lowenstein, F.R.S., became Professor of Zoology and Comparative Physiology in Birmingham.

Hindle devoted much time to the honorary posts which he held and particularly to those connected specifically with animals. His main objective in founding the Zoological Society in Glasgow was to create the necessary atmosphere of enthusiasm for the institution of a zoo in that city. He managed to acquire, in 1939, Calder Park, an estate of 93 acres on the eastern boundary of
Glasgow. The area comprises hills, a river, a lake, woodland and flat ground suitable for the enclosures. The war caused an upset in the plans for its development, but Hindle kept interest from flagging by public lectures on wild animals including some on the fauna of the Highlands. Unfortunately, Hindle left Glasgow for the London Zoo in 1944, before the plans materialized and it was not until three years later that Calder Park Zoo was opened by his successor, the Earl of Dumfries.

Hindle took a very special interest in the Institute of Biology and attended its meetings regularly from 1951 until a few weeks before his death; he enjoyed meeting the younger members and his presence undoubtedly contributed to the rapid growth in the membership (now nearing 10 000).

Hindle spent many hours on editorial work from early in his career. He became assistant Editor of *Parasitology* in 1912, joint Editor in 1919 and remained on the Editorial Board until 1968. He was a Sectional Editor of the *Tropical Diseases Bulletin* for many years and his critical abstracts of papers on yellow fever and relapsing fever were avidly read by tropical workers. During the formation of the Glasgow Zoo, he founded the magazine *Zoo News*; when he was professor of biology in Egypt he became the editor of the *Cairo Scientific Journal*. Hindle was greatly disappointed by the failure of an international review of the Arts, Sciences and Letters, entitled 'One World'. He had been intimately concerned in its groundwork and was on the editorial board. A dummy copy was prepared in 1948, but in spite of support from 25 countries, the time proved to be unfavourable and the necessary finance could not be raised.

**Research**

Hindle is an example of eclecticism and opportunism in science in that the nature of his research was governed by the conditions in which he happened to be living at the time. He left, in his diverse posts, a trail of interesting discoveries relating to the local environment, but a biological thread connected them all. Thus, as an undergraduate at the Royal College of Science of London (since amalgamated in the Imperial College of Science and Technology), his quick eye detected an abnormality in the morphology of a fresh-water crayfish supplied to the students for dissection, and he described this condition in his second paper, published in 1908 in the *Zoologischen Anzeiger*. Subsequently, the following appointments were associated with particular aspects of Hindle's work:

1907–1908  Research Assistant at the Liverpool School of Tropical Medicine. He made observations on mammalian trypanosomes based on a strain of the so-called *Trypanosoma dimorphon* brought back from West Africa and maintained in experimental animals in Liverpool. C. A. Hoare, F.R.S., subsequently pointed out that this organism was *T. brucei*. Later in Liverpool, he and Anton Breinl worked on the rôle of the rat louse (*Haematopinus spinulosus*) in the transmission of *Trypanosoma lewisi*, but Hindle had to abandon this work before it was completed owing to his departure for the United States. However,
later it was shown that no cyclical development occurs in the louse. When Hindle and Patton were investigating kala azar in China in 1926, they found a new species of trypanosome in the striped hamster and named it *T. cricetuli*.

**1909** Assistant in the Marine Biological Station, La Jolla, California: unpublished observations on plankton (especially the Euphausiaceae and Mysidaceae).

**1910** Instructor in Zoology at Berkeley, University of California: Ph.D. thesis on trypanosomes and on artificial parthenogenesis, based on observations of the eggs of *Strongylocentrotus purpuratus* at the Hergstein Research Laboratory. This work was supervised by Professors J. Loeb and C. A. Kofoed.

**1910–1913** Beit Memorial Research Fellow, Quick Laboratory, Cambridge, and Kingsley Bye Fellow of Magdalene College. In collaboration or under the guidance of Professor G. H. F. Nuttall, F.R.S., he studied the morphology and transmission through mucous membranes of *Trypanosoma gambiense* and he was one of the first to demonstrate, biometrically, the existence of the three types of the organism as seen in the blood. Later, in the same Laboratory, Hindle became deeply interested in relapsing fever and other spirochaetoses; Nuttall had begun experiments on the organisms and their transmission by arthropods, a few years earlier, and had inspired Hindle with an interest in this subject, which persisted through much of his research life. His major discoveries on these infections are related below (pp. 227–228).

**[1914–1919** Service as an officer in the Royal Engineers during World War I. During the last years of the war he was stationed in Palestine and for the first time experienced subtropical conditions.]

**1919–1924** Professor of Biology, School of Medicine, Cairo. The First World War had interrupted the tenor of Hindle’s researches, and in these successive years in Egypt, it is clear that the administrative duties involved in the transformation of an out-of-date department into a modern school occupied most of his time. Also he did much teaching and his publications during these years were almost limited to elementary books for students, including one on botany, which he wrote with H. Munro Fox, F.R.S. His sole piece of original work was a description of myiasis in an Egyptian toad. It is rather surprising that Hindle was apparently unaffected by the fever of excitement induced by Howard Carter’s discoveries at Luxor which coincided precisely with his own sojourn in Egypt. There are many references to ‘flies and disease’ in the papyri and on the walls of tombs and temples; there exist also actual amulets (dating probably from the Middle Kingdom) of tabanid flies which are now known to be vectors of trypanosomes of camels and horses. It is almost inconceivable that he was unaware of these facts. Unfortunately few of his colleague or even pupils at the School of Medicine at that time are alive today and recent enquiries in Cairo about his general activities there elicited no response.

The foregoing decade of infertility was followed by years of intense scientific activity, as though he were making up for lost time. Hindle’s best work was accomplished during this period, i.e. between the ages of 38 and 48.
1924–1925 Milner Research Fellow at the London School of Hygiene and Tropical Medicine. On his return to England, he rejoined Nuttall and made a study of the alimentary tract of the chicken tick, *Argas persicus*, and the reasons behind its insusceptibility to bacteria. He continued this work in London in conjunction with the mycologist, J. T. Duncan, and followed it up with observations on *Leptospira* spp. with the help of the protozoologists, J. Gordon Thomson and Andrew Robertson. The *Leptospira* were obtained from various sources including water from the Thames and in the slime coating a bowl placed underneath a dripping ice-chest at the London School (in the old premises in Endsleigh Gardens).

1925–1927 Member and eventually Leader of the Royal Society’s Kala Azar Commission in China. Hindle had by now acquired a considerable reputation in tropical medicine, particularly in relation to the arthropod-borne diseases. He and Major W. S. Patton, late of the Indian Medical Service and subsequently Director of the Entomological Department of the Liverpool School of Tropical Medicine, investigated the problem of visceral leishmaniasis (= kala-azar) in the Province of Shantung in North China. Their observations were practically confined to the development of the parasite in various indigenous species of sandflies and to attempts at transmission to hamsters. The human aspects of the disease were scarcely touched on, chiefly because of the widespread political disturbances in China at that time and to the general distrust by the local population of western medicine. Hindle was impressed by the contrast of the mediaeval walled city with the heads of recently executed magistrates hanging on the gates, and aeroplanes circling overhead. A few patients were placed at the disposal of the Commission by mission doctors. It is interesting to note that at the time of these researches (and even years later) Hindle paid no attention to the question of animal reservoirs of the infection, either of dogs or of the wild animals of the endemic areas. The significance of Hindle’s researches on leishmaniasis and sandflies is discussed below (p. 225).

1928–1933 Beit Research Fellow in Tropical Medicine at the Wellcome Bureau of Scientific Research (Director, C. M. Wenyon, F.R.S.). Hindle began his studies on viruses early in 1928 and made his major discoveries on the yellow fever virus and the prophylactic vaccine during the subsequent five years. The work is described below (pp. 225–227).

1934 At the National Institute of Medical Research, where he reverted to research on relapsing fever spirochaetes.

1935–1944 Regius Professor of Zoology and Hunterian Curator in the University of Glasgow. The transition to this formidable appointment, held for the previous thirty years by the classical zoologist, J. Graham Kerr, F.R.S., was something that only a man with Hindle’s personality could have achieved with distinction. But it took time for the new broom to sweep away the long established traditions, and, as in Cairo, Hindle was plunged into teaching and
administrative problems which sterilized his practical research life. Moreover, the outbreak of World War II also deflected him once again from research, and his ardent patriotism took him back into military life. His research mind, however, remained open and he was poised on the brink of interesting discoveries. There were at least four which he might have pursued. Thus in his description of the fauna of the Argyll National Forest he mentions the fluctuations in the population of voles (*Microtus agrestis*) and suggested that the sudden decline in numbers was due in part to an 'epidemic' disease caused by 'a minute animal parasite living in the brain'. Presumably he was referring to *Toxoplasma microti* (= *Frenkelia microti*) described a few years earlier by his Wellcome colleague, Marshall Findlay, from voles near Lake Vyrnwy in Wales. Hindle had specimens sent to his laboratory in Glasgow, but this protozoon was absent though *Sarcocystis* was present; if he had waited for the 7-year epizootic cycle to return he would probably have encountered the organism and might have opened a new chapter in protozoology—a chapter which still remains obscure. A second uncompleted project concerned trichiniasis in man, epidemics of which had broken out in Carlisle; he examined the diaphragms of people at autopsy in Glasgow, but after 50 negative results abandoned the work. He obtained specimens of *Sacculina* from the Millport Marine Station and inoculated them into rabbits in order to study the immune response, but this work also came to nothing. Finally, he collected lice off the clothing of vagrants and found a 20 to 1 female to male sex ratio among them; a similar discrepancy was observed also in *Haematopinus equi* in horse clippings. This was a continuation of the work he had done in Cambridge 20 years earlier, and led to almost his last scientific paper on mitotic division following meiosis in human lice. The latter was written in collaboration with Guido Pontecorvo, F.R.S., whom he accepted into his Department in 1942 from internment in the Isle of Man.

1944-1951 Scientific Director, Zoological Society of London, where he was responsible for making drastic changes in policy, particularly in regard to the scientific aspects of its activities.

The foregoing list of Hindle's appointments indicates that he did not like to stay in one place for very long, and it is not remarkable that he left his chair in Glasgow to return to London. He had still twelve years to go in the former before retirement, but he had long been interested in zoological parks and their potential facilities for zoology as a whole. He had always cared for animals—he first paper was on the sea-cucumber and his last ones were on the golden hamster (*Mesocricetus auratus*). Hindle's name is closely linked with the latter animal and the usual inaccurate legends have arisen over his rôle in preserving the animal from extinction. His own account (see Bruce & Hindle, 1934) gives the true story. Specimens (an adult female and twelve young ones) were dug out of a burrow in the desert near Aleppo by Aharoni in 1930 and were taken to the Hebrew University, Jerusalem. Saul Adler, F.R.S., and Aharoni colonized them successfully in the laboratory and the former brought two pairs in
1931 to England where he gave them to Hindle. From this stock have been derived all the golden hamsters of Europe and elsewhere. The animal has proved to be an invaluable laboratory host for experiments with leishmaniasis and was therefore of paramount interest both to Adler and Hindle.

MAJOR ACHIEVEMENTS

Three major fields in Hindle's research can be recognized: leishmaniasis, yellow fever and spirochaetoses. Each one today falls into a separate discipline, but all three are arthropod-borne infections. It is for this reason that Hindle was drawn to their study; they satisfied his desire for variety and they attracted his basic interest in entomology.

Leishmaniasis

The Chinese hamster (Mesocricetus griseus) was found to be very susceptible to Leishmania donovani of Chinese origin and was used as the test animal throughout the work of the Kala Azar Commission in China. Kala-azar was shown to be largely a rural disease occasionally erupting into epidemics; the age incidence resembles the Indian form in that cases occur quite commonly after the first few years of life (unlike the L. infantum of the Mediterranean region). The most important results concerned the transmission of the infection of Phlebotomus spp. Hamsters were largely used in the transmission experiments and the full cycle of the parasite was seen in P. chinensis; on the contrary, P. mongolensis proved to be a poor host as little migration forwards to the mouth parts occurred in this species of fly. Like the results of the Indian workers, no transmission to clean hamsters by the bite of infected flies could be obtained. Hindle found good evidence that congenital transmission of kala-azar takes place and also that some such cases underwent spontaneous cure. This was a novel idea at the time and fitted in well with the theory of 'infections inapparentes' of Charles Nicolle. Hindle compared the behaviour of different strains of Leishmania in the Chinese hamster and in two species of Phlebotomus and demonstrated the much greater susceptibility of the local strain of parasite to the local vectors as compared with Indian or Tunisian strains — thus indicating that there must be a biological (and geographical) relationship between the parasite and its invertebrate host. This fundamental principle of parasitology was only just becoming recognized and Hindle realized its great importance.

Yellow fever and other virus diseases

Although the existence of filterable viruses had been recognized as early as the closing years of the nineteenth century, Hindle did not seem to have paid any attention to them until he was given a place by Sir Henry Wellcome in the Wellcome Laboratories of Scientific Research in January 1928. Here he met virologists including G. Marshall Findlay, with whom he collaborated in work on yellow fever and feline distemper. Stokes, Bauer & Hudson (1928)
had just demonstrated the susceptibility of the rhesus monkey (Macaca mulatta) to yellow fever, and Hindle was anxious to work on the laboratory aspects of this disease in his new laboratory in London. He therefore wrote to A. W. Sellards (of the Harvard Medical School) who was investigating yellow fever in Senegal, asking him for a strain of the virus. Sellards accordingly brought infective material, from a monkey dying of the disease, frozen in salt and ice, by sea from Dakar (a 12-day passage) to London where it was inoculated into two rhesus monkeys. These both became ill and died within a few days of the disease; this result demonstrated that virus could be kept alive for 12 days when kept at a temperature of $-3 \degree$C. Another useful result of his early experiments was the demonstration of freeze-drying as a method of preservation of infective material for at least three months.

Hindle spent the next year in intensive research on yellow fever and delivered his results at a famous meeting of the Royal Society of Tropical Medicine and Hygiene at Manson House in January 1929. The most important discovery was that the inoculation into a monkey of a formalinized or phenol glycerinized vaccine confers a high degree of protection to the animal when subsequently inoculated with the virus or exposed to the bites of infected mosquitoes. Aragão (1928) was apparently the first person to test the value of this vaccine in the field; he confirmed its value first on human volunteers at the Instituto Oswaldo Cruz and then on the population of Rio de Janeiro where an epidemic had broken out. The vaccine was subsequently used prophylactically in West Africa, and it underwent many changes in its mode of production in the following years. Hindle and Findlay also employed living virus and immune serum with success; the latest methods have discarded the use of animals by the substitution of chick embryos and tissue culture. It is now probably one of the most successful vaccines in existence, both in protective value and duration of effect.

Hindle carried out transmission studies on the Dakar strain of yellow fever, using Aedes aegypti originating from India and West Africa respectively. The absence of the disease from India had been attributed to the insusceptibility of the local mosquito, but these experiments showed that both races were susceptible to the virus. During these and subsequent experiments, Hindle and two laboratory attendants became accidentally infected. One of the latter died, and as a result, S. P. James, F.R.S., Adviser on Tropical Medicine to the Ministry of Health, recommended that work involving insect transmission should be moved from densely populated London to the Wellcome Laboratories at the Field Station in Kent where the risk of the spread of the infection would be correspondingly less. The sera of the two patients who recovered were used in a ‘rhesus protection test’ and clearly demonstrated the presence of immunity; this was the forerunner of the widely employed ‘mouse protection test’ of Sellards (1931).

Hindle described briefly the course of his own mild attack of yellow fever which simulated influenza. It was followed by hyperaesthesia of the skin over various parts of the body and this symptom persisted for three to four weeks.
The pathology underlying the symptom remains unknown, although it has been reported in other mild cases of the disease.

Hindle's observations on the behaviour of the yellow fever virus in *Aedes aegypti* confirmed that transovarian infection did not occur, illustrated the course of infection in the mosquito, and disclosed the surprising inability of immune sera to neutralize the virus in the mosquito once the infection had become established, i.e. escaped from the lumen of the gut.

Hindle's personal experience with yellow fever had shown him that mild infections could occur and he was one of the first to appreciate the size of the submerged or occult part of the iceberg as compared with the visible or patent part consisting of the severe and fatal disease. He realized also that mosquitoes other than the cosmopolitan *Aedes aegypti* could be infected with the virus and that primates other than man are susceptible to its effects. Strangely enough however, he was blind to the significance of these laboratory findings. Hindle was not a 'field man' and his mind was not 'prepared' for the concept of 'jungle yellow fever'.

Later in collaboration with Marshall Findlay, Hindle studied feline distemper in tigers, lynxes, ocelots, leopards and other wild felines from the London Zoological Gardens and ruled out a bacterial aetiology of the disease; they concluded that the disease was due to a filterable virus and was transmitted by coughing or by fomites. Using domestic cats, they showed that the virus can be maintained in 50% glycerine, and a vaccine was later developed by T. Dalling on the basis of this work.

**Spirochaetoses**

Hindle started work on the transmission of *Spirochaeta duttoni* (now known as *Borrellia duttoni*) in 1910 in the laboratory of G. H. F. Nuttall and he was largely instrumental in showing that the infection (causing human relapsing fever in tropical Africa) is not contracted via the saliva but by contamination of the site of the bite by fluid thought to have escaped from the Malpighian tubules. This fluid contains numerous spirochaetes. It is usually stated today that the coxal glands are the place of origin of the spirochaetes, but Hindle went into this question carefully and came to the conclusion that their secretion—the coxal fluid—merely bathes the under-surface of the tick when it is feeding and washes the white Malpighian secretion into the wound. This opinion was shared by Sir William Leishman, F.R.S. The experiments were conducted at 21 °C; at higher temperatures (e.g. 35 °C), the salivary glands may also become invaded by the organisms.

Among other interesting observations that Hindle made in the Quick Laboratory was the inhibitory effect of *S. duttoni* on concurrent infections of *Trypanosoma brucei*. This subject has again been studied in recent years and has various applications in the realm of immunology. He extended his observations on immunity in later years and isolated a specific soluble haptene from *Leptospira* present in London tap water. Hindle was particularly interested in his discovery that 30% of the ticks (*Ornithodoros moubata*) used in his experiments...
were immune to infection with the spirochaete and ascribed this (as did the German investigators, Schuberg and Manteufel in 1910) to an active immunity acquired by exposure to previous infections. However many years later, Walton (1949) in East Africa demonstrated that different races or subspecies of the tick existed which had varying degrees of susceptibilities to the organism.

Hindle had hoped to work out the full life cycle of the human relapsing fever spirochaete in the tick, but owing to the presence of insusceptible ticks in his colonies, he made the observations instead on *Spirochaeta gallinarum* and the chicken soft tick—*Argas persicus*. He studied first the behaviour of the parasite in the blood and established that the mode of division was by transverse fission, followed at the time of crisis by transformation of the spirochaete into a number of coccoid, spore-like bodies. The latter process, however, was observed best in the tick. The spirochaetes first bore their way through the gut wall into the haemocoelomic fluid; thence they pass to the various organs and break up into the coccoid bodies, particularly in the gonads, Malpighian tubules or even in the lumen of the gut. If the eggs of these ticks are incubated at 37 °C for a few days, larvae emerge in which typical spirochaetes are found; thus, like *S. duttoni* in *O. moubata*, hereditary transmission to the offspring occurs. An invisible stage of the parasite had been postulated by many workers, but it is now generally thought that Hindle was right in stating that the 'negative phase' was apparent, not real, and was accompanied by the presence of a minute number of spirochaetes. He was reluctant however for years to abandon the concept of persistence of the 'granular stage'.

Hindle was responsible for bringing a certain degree of order into the confused nomenclature of spiral organisms of both parasitic and free-living modes of life, and his system, first published in 1931, is still of fundamental importance. Hindle realized the close relation between spirochaetes and rickettsiae. After World War I, he had the opportunity of working on *Rickettsia quintana* (the cause of trench fever) and its transmission by lice. He was impressed by the negative phase of the parasite for four days in *Pediculus humanus* and was later to compare it with the, perhaps, similar phenomenon in relapsing fever. He extended his researches to *Rickettsia* spp. in the lice of other animals and found similar infections in the lice of sheep, horses and goats (the last two harbouring new species). He thought that the human rickettsiae were originally of animal origin, and this is one of his few speculations on animal reservoirs or origins of human disease (the word 'zoonosis', in fact, never entered his vocabulary).

**Unfinished work**

In the turmoil of his heavy responsibilities in Glasgow before and during the Second World War, Hindle started several promising projects, most of which he was unable to complete (see p. 224). Other observations which were not followed up, included the following:

During a stay at Dax Spa near Bordeaux in the summer of 1930, he amused himself by observing the free-living amoebae and other creatures living at a...
record temperature in a pool of hot water in the market place. Among the thermophilic organisms was a species of *Hartmanella* which he continued to study in London. This work might have formed the starting point of research into the free-living amoeba-flagellates which are known today to be responsible for a particularly fatal form of meningitis in divers or water-skiers. Another opportunity was lost when he discovered the ‘oocysts’ of *Isospora bigemina* in the faces of a dachshund with dysentery. He drew attention to two peculiarities: (1) the formation of the oocysts in the deeper tissue of the intestinal villi and their liberation only when the cells break down and (2) their small size, namely 10–16 μm × 7–10 μm. The latter measurements are precisely those of the sporocysts of *Sarcocystis fusiformis* and it is fairly certain that Hindle’s parasites in the dachshund represented this stage in the life of *Sarcocystis*. The solution had to wait a further forty years, when Rommel & Heydorn (1972) demonstrated in Berlin the identity of the two parasites.

**PERSONALITY**

Over twenty years were to elapse between the termination of Hindle’s last scientific post as Director of the Zoological Society of London and his death in 1973. His temperament, inclinations and experience had thoroughly prepared him for so-called retirement, for now he could indulge freely his love of people, entertaining and being entertained, and in playing an even more active rôle in the various organizations with which he was associated. It would be easy to dismiss these as the activities of a ‘Club Man’ or avid participant of meetings or soirées. But the club or society merely gave him the opportunity of meeting his friends, acquaintances, colleagues or young students, all of whom appreciated his generosity, wisdom and charm. Landsborough Thomson described him, in an after-dinner speech, as ‘the biologist about town’ (Obit. Fellows of the Royal Society of Edinburgh, 1974).

He had simple tastes, but catholic interests and I doubt if he was ever bored. He liked animals and was fond of children, though probably he preferred the former. He had quite a collection of toys, like Dick the Diver, birds, grasshoppers and divining bamboos, but he was not a collector in the conventional sense either of works of art or of scientific specimens. He was a sound bridge player, but his interest in the game waned in later years. He used to say that ‘exercise was not good for the health’, but he enjoyed picnics, especially from the car, for he had a passion for motoring and it grieved him when he had to give up driving in the last year of his life. He played ice hockey in his younger days and skied at Lenk, and while not a horseman of the calibre of his old friend Munro Fox, he was mounted in World War I.

There were always two sides to Hindle’s personality: although most people thought of him as a sociable person, Alec F. Haddow, F.R.S., was probably nearer the mark when he described him as in many ways an enigma; Haddow also commented on the meticulous technique which he employed in the transmission studies in leishmaniasis whereby not a single false positive became evident—on the other hand, some of his colleagues were very critical of his
laboratory practices; his natural habitat seemed to be London, yet he travelled far and wide and the Hindle glacier of South Georgia in Antarctica was named after him by Duncan Carse in 1958.

Hindle showed great courage at various times of his life, as in the First World War and in the riotous situations with which he was faced in China. And he was one of that gallant band of intrepid workers on yellow fever (and before his own discovery of the highly protective vaccine!).

Hindle could be abrupt, gruff and blunt. But unpleasantness was quickly dissipated by a sudden smile and chuckle, and he never bore a grudge. He was a likeable man, perhaps because he had no compelling urge for priority and he was most careful to give credit both to his predecessors and to his co-workers.

Hindle's assistant (Mr MacKinnon) in Glasgow said that he was an adequate though not a highly skilled technician, and that, in spite of his thick fingers, he was able to splenectomize a small laboratory animal in a flash. He was not renowned as a scientific artist, yet his Indian ink drawings of parthenogenesis with mitotic figures are delicate and accurate. He loved playing his Ibach grand piano, especially piano duets and he was a good accompanist, being an excellent sight-reader. He preferred classical to modern music, and particularly liked the works of Beethoven, Schumann and Chopin. The Andante from the \textit{Sonata Op. 13 (Pathétique)} was played at his funeral service. Hindle also enjoyed going to the opera and particularly to the music dramas of Wagner. He often went to the theatre, but preferred the cinema in his last years, when his hearing became defective.

Club life appealed to Hindle because he was essentially gregarious. His name is associated with a number of society clubs. He was elected to the ancient Royal Society Club in 1945; he was Honorary Secretary and Treasurer of the Geographical Club from 1952 to 1957; he was a keen member for over 40 years of the Dining Club of the Zoological Society of London where he was frequently to be found, before, during and after his official appointment at the Zoo. He was admitted to the Livery of the Farriers' Company of London in 1944 and he appreciated its ancient traditions dating back to the fourteenth century; he was one of the few liverymen who could shoe a horse. His London Club was the Athenaeum where he was a prominent and much esteemed member. He died suddenly in a taxi on 22 January 1973 on his way to lunch with Lady (Charles) Darwin.

Hindle was elected a Fellow of the Royal Society in 1942. He was made an Honorary Fellow of the Imperial College of Science and Technology and of the Institute of Biology. He received the Croix Civique de Belgique (1st Class) in 1931, for his help (including vaccination with his new product) in controlling an epidemic of yellow fever at Matadi near the mouth of the River Congo. He was Rhodesian Gold Medallist in 1912, and was the William Withering Lecturer in the University of Birmingham in 1935. He was awarded the Médaille Geoffroy St Hilaire (en or) de la Société d'Acclimatation de France in 1951. He was elected a Membre Correspondant of the following: Société de Pathologie Exotique (Paris), Société Belge de Médecine Tropicale and
Société Entomologique d’Egypte. The various honorary posts he occupied are shown in table 1, p. 220.

Soon after demobilization from the Army in 1919, Hindle married Irene Margaret Twist. She was the only daughter of John Twist of Prescot and first cousin of Sir John Graham Kerr, F.R.S., whom, in later years, Hindle was to succeed as Regius Professor of Zoology in Glasgow. Mrs Hindle died in 1933. He married as his second wife, Ellen Mary Theodora (née Schroeder) in 1936; there was a judicial separation in 1951.

I am particularly indebted to Miss Phyllis Barclay-Smith, O.B.E., for personal details of Professor Edward Hindle of whom she was probably the closest friend during the last twenty-five years of his life. I owe much, too, to the remarks of Dr Kenneth Mellanby in a moving tribute to him at the Memorial Service at St James’, Piccadilly. Help is also acknowledged from various colleagues and friends, including Professor D. S. Bertram and Professor A. J. Haddow, F.R.S., and from his Chief Technician in the Department of Zoology, University of Glasgow, Mr A. MacKinnon.

This memoir was largely written at Ross Priory, Loch Lomond (University of Strathclyde); I am grateful to the University authorities and in particular to Professor W. M. Hutchison for the facilities and help provided.

The photograph is from the Glasgow University Museum, ca. 1936.

I am very grateful to the librarians (especially Mrs Cynthia Anderson) of the Library of the University of Glasgow for the preparation of the bibliography. Letters to the editors of the relevant journals, laboratory demonstrations and contributions to discussions have not been included.

BIBLIOGRAPHY


The transmission of Spirochaeta duttoni. Parasitology 4, 133–149.


(With R. C. Lewis) Note on ‘Crithidia’ cleti n. sp. parasitic in the alimentary canal of Cletus varius, Dall. Parasitology 5, 109–113.


1914 *Flies in relation to disease; bloodsucking flies*, xv, [1], 396 pp., illus. Cambridge University Press.


Note on a leg abnormality in *Acanthia lectularia*. *Parasitology* 7, 228–239.


Note on the colour preference of flies. *J. Hygiene* 14, 46–47.


(With G. Merriman) The range of flight of *Musca domestica*. *J. Hygiene* 14, 23–45.


(With G. H. F. Nuttall) *Serological Museum Bull.* 6, 5.


1919 Sex inheritance in *Pediculus humanus var. corporis*. *J. Genetics* 8, 267–277.


Notes on *Rickettsia*. *Parasitology* 13, 152–159.

1922 (With H. Munro Fox) *A laboratory notebook of elementary botany*. 3 pp., 1, 2–114, 1 p. Cairo: Government Press.

1924 Myiasis in *Bufo regularis* caused by a tabanid larva. *Parasitology* 16, 111–112.

1925 (With J. T. Duncan) The viability of bacteria in *Argas persicus*. *Parasitology* 17, 434–446.


Biographical Memoirs

1932 An attempt to demonstrate residual virus in monkeys which had recovered from yellow fever. Br. J. exp. Pathology 13, 135–140.


Isospora bigemina from the dog. Proc. R. Soc. Med. 26, 204.


1947 The golden hamster. In: The UFAW handbook on the care and management of laboratory animals (1st ed.).

