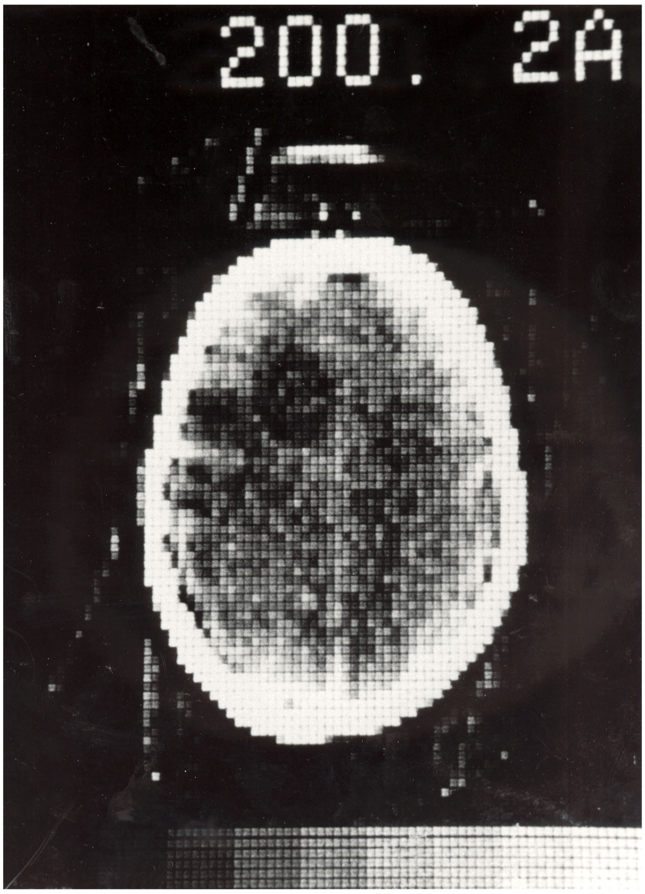
The Invisible Light



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Contents

Editorial Notes

I hope you like this issue of The Invisible Light.

I was very impressed by the paper on William Crookes by the late Derek Guttery. I have been more and more aware of the depth of his knowledge of radiology and what a great loss his death has been to the radiological community. It is also sad to record the death of Sir Godfrey Hounsfield who a Friend of the RHHCT. The cover illustration is of the first clinical CT image.

There are plans to change the name of the Radiology History and Heritage Charitable Trust. We will remain a charitable trust but will change our approach a little. We are becoming “The British Society for the History of Radiology” with elected officers. The ‘Friends of the RHHCT’ will automatically become members of the BSHM and we will have a yearly AGM. I will keep you informed of developments.

Adrian Thomas

Dr Adrian M K Thomas BSc FRCP FRCR

Consultant Radiologist
Department of Nuclear Medicine
Princess Royal University Hospital
Farnborough Common
Orpington
Kent BR6 8ND
UK

tel: +44 (0)1689 863653
fax: +44(0)1689 863320
URL: www.rhhct.org.uk
mobile : +44(0)7951 285720
e-mail : adrian.thomas@btinternet.com

The RHHCT web site is to be found at: www.rhhct.org.uk

The British Society for the History of Medicine:

The 2005 BSHM Congress is from 1st – 4th September 2005 and is in Exeter. Do put the date in your diary and come along and present a paper! We always have a good time – and it is important that papers are presented with a radiological theme to ensure that radiology history is represented. The secretary is: Dr. Ann Ferguson, New Barn, 39a Grange Road, Broadstairs, Kent CT10 3ER annferguson@doctors.org.uk

Witness Seminar Programme 2004-2005
History of 20th Century Medicine

Development of Physics Applied to Medicine
5th July 2005
2- 6 pm: 125 Euston Road, London
Organisers: Prof John Clifton & Dr Daphne Christie

Space is limited. If you wish to attend please contact Mrs Wendy Kutner at the Wellcome Trust Centre for the History of Medicine, University College London, 24 Eversholt Street, London NW1 1AD (020 7679 8106) w.kutner@ucl.ac.uk

Recent Historical Books and Articles

Books

Great Physicists: The Life and Times of Leading Physicists from Galileo to Hawking
William H Cropper
Oxford University Press (2004)
ISBN: 0-19-517324-4
This is a lively history of modern physics, as seen through the lives of thirty men and women from the pantheon of physics. William H. Cropper vividly portrays the life and accomplishments of such giants as Galileo and Isaac Newton, Marie Curie and Ernest Rutherford and Albert Einstein, right up to contemporary figures such as Richard Feynman, Murray Gell-Mann, and Stephen Hawking. A book to be recommended.

Explaining the Universe: The New Age of Physics
John M. Charap
Princeton University Press (May 2004)
ISBN: 0691117446
John Charap offers a panoramic view of the physicist's world as the twenty-first century opens. The view is entirely different from the one that greeted the twentieth century. The opening chapters are a very good summary of the development of modern physics. The second chapter 'Physics 1900' gives an account of the world of Curie and Roentgen and asks 'What were the hot topics for physics in 1900?' An excellent book.

Manifesting Medicine (Artifacts S.)
Robert Bud (Editor), Bernard Finn (Editor), Helmuth Trischler (Editor)
Publisher: Science Museum (August 31, 2004)
ISBN: 1900747561
The 'Artifacts' series is sponsored by the Science Museum in London, UK, the Deutsches Museum in Munich, Germany, and the Smithsonian Institution in Washington DC, USA, with help from professional historians in other museums and elsewhere. In this book, five authors write about sets of museum character: early blood transfusion apparatus, a plastic human replica,

the Geiger counter, open-heart surgery equipment and packaging for the Pill. Case by case, the use of the objects focuses attention not only on their medical purpose, but also on the meanings they held for all who confronted them. Johannes Abele has written a thoughtful chapter on "Safety Clicks. The Geiger-Müller tube and radiation protection in Germany, 1928-1960"

Degrees Kelvin: A Tale of Genius, Invention and Tragedy
David Lindley
Publisher: Joseph Henry Press (April 2004)
ISBN: 0309090733
Lord Kelvin was hailed as a genius and received a copy of the First Communication from Wilhelm Roentgen. He was the greatest physicist of his time. Charismatic, confident and handsome, William Thomson was elevated to the peerage. As the 19th Century drew to a close, it seems Lord Kelvin's scientific mind shut down. He was publicly doubtful about the existence of atoms, and refused to believe that radioactivity involved the transmutation of elements. He was also vehemently opposed to the doctrines of Charles Darwin and spent his last years arguing that the Earth and the Sun could not be more than 100 million years old. Silvanus P Thompson wrote "The Life of William Thomson, Baron Kelvin of Largs" in 1910 which is full of detail. David Lindley gives an interesting account of this remarkable man, a central figure in Victorian science.

Radiology at Boston City Hospital, University Hospital, and Boston University School of Medicine – A History.
Department of Radiology, Boston University (2000)
ISBN: 0-9702141-0-3
Otha W Linton MSJ

Radiology at Massachusetts General Hospital 1896-2000
The General Hospital Corporation (2001)
ISBN: 9715150-0-X
Otha W Linton MSJ

Radiology at the Brigham 1913-2002
Department of Radiology, Brigham and Women's Hospital (2003)
ISBN: 0-97489-0-X
Otha W Linton MSJ

Radiology at the University of California, San Francisco 1899-2003
University of California, San Francisco (2004)
ISBN: 0-9752709-0-7
Otha W Linton MSJ

A Century of Radiology at the University of Pennsylvania
Department of Radiology, University of Pennsylvania (1999)
ISBN: 1-890705-01-2
Otha W Linton MSJ

Otha Linton was for 35 years a senior executive of the American College of Radiology. One of his last projects for the ACR was the development of the year-long Radiologic Centennial celebration in 1995. These departmental histories are of great interest and Otha has done a great service to the radiological community. As well as a chronology of the various hospitals there is an attempt to relate the development to social and political changes. I particularly enjoyed the volume on the University of Pennsylvania.

Articles

X-ray ephemera, with particular reference to apparatus.
AMK Thomas & R F Mould
Current Oncology (2004) 11:14-33
Devoted to the subject of ephemera in radiology – dare I say …… one of my current interests!

Chronic alpha-irradiation of the nervous system from thorium dioxide
E H Jellinek
Journal of the Royal Society of Medicine (2004) 97:345-349
A most interesting article devoted to the long-tern effects of Thorotrast ventriculography. Two cases and their pathology are presented.

The British Journal of Radiology and the Second World War: a radiologist's perspective.
I J Kenney
British Journal of Radiology (2004) 77:499-503
Looks at the role of the oldest journal of radiology at a time of conflict.

Wilhelm Conrad Röntgen and the 1914 affair.
I Isherwood
Journal of Medical Biography (2004) 12:90-94
An account of the involvement of Wilhelm Röntgen in the messy propaganda of the Great War.

Editorial: Pioneers and their legacy in radiology.
Adrian M K Thomas
Journal of Medical Biography (2004) 12:125

The life and work of the Birmingham radiologist Dr James Brailsford (1888-1961).
HM Kapadia, K Banerjee & RG Arnott
Journal of Medical Biography (2004) 12:128-135

THE GREAT ATOM LEAK COVER UP
According to the Daily Express 19 January 1984

by W Alan Jennings

Former Head, Director of Radiation Science
National Physical Laboratory

There have been many ‘radiation leak’ incidents over the years, but for sheer magnification the following story must be hard to beat. Indeed, it may be difficult to believe, but it is **entirely factual**. It relates to an event at the National Physical Laboratory in Teddington in 1984.

Whilst monitoring an old laboratory building once used for radiochemical work, including the analysis of uranium ore, a small patch of radioactivity was detected on the concrete floor. The radiation level, due to α-rays (which scarcely penetrate a piece of paper) was trivial but nevertheless correctly reported to management. In accordance with good practice, the building concerned was temporarily closed as a precautionary measure. Unfortunately this meant that the staff concerned could not retrieve their belongings. As a result subsequent conversations between them at the nearby Queen Dowager public house were by chance overheard and reached the ears of the press. Sensing a ‘radiation leak’ story, the press proceeded to ferret for information from all possible sources, from the landlord of the public house to Whitehall departments who had yet to hear about the issue. The α-activity in question was bound to the host surface and therefore could not be ingested or inhaled. In fact, from the standpoint of the public, the matter was manifestly irrelevant.

However, on Thursday 19th January 1984, the Daily Express, claiming an ‘exclusive’ (“You always read it FIRST in the Express”) ‘revealed all’ with an incredible and utterly irresponsible banner headline on its front page: *(Figure 1)*


January 19, 1984

DAILY EXPRESS

Thursday January 19, 1984 • 18p • TV Pages 20 and 21

THE VOICE OF BRITAIN

You always read it FIRST in the Express

The great atom leak cover-up

Radiation ‘100 times above normal level’

Families at risk near secret plant

by Tony Dawe

Figure 1.

“The great atom leak cover up – Families at risk near secret plant”

A 2-page report included the following points:

- ‘A radiation leak has closed down part of a secret research centre in a London suburb!’
- ‘Particles of potentially lethal uranium were found in an NPL building only 20 yards from homes. The centre itself is surrounded on three sides by residential streets, with a school close by.’
- ‘Radiation levels 100 times greater than normal background levels were revealed in corners of the building’ (attributed to an employee who ‘must remain anonymous’).
- ‘The most important effect of too much radiation on people’s health is cancer. You can say that such levels would cause 100 times more cancers in the population.’ (attributed to Dr William Connel of ‘Friends of the Earth’.)
- ‘The NPL leak is bound to increase public concern at the siting of research centres using radioactive materials close to residential areas.’
- ‘The scare could further anger people in north London who are campaigning against plans to switch research on dangerous diseases from Porton Down, Wiltshire, to a new laboratory in suburban Colindale.’

The flowing day, 20th of January, the Daily Express ran another banner headline:

“New A-leak puts six plutonium workers at risk- Top level probe at Aldermaston”

‘This news comes only a day after the Daily Express revealed details of a radiation leak at the National Physical Laboratory in Teddington, London, which government officials tried to cover up.’

This led to an editorial in the same issue headed *“Away with this secrecy”*. Attacking the nuclear energy business, it claimed that its ‘record of cover ups is appalling. Small wonder that it provides grist for the scaremongering mills of sensationalist filmmakers.’

On the same day, 20th of January, the Daily Mirror also reported the Aldermaston story: **“A-plant leak scare – probe at top secret base”**, together with an editorial headed *“The secret horror”,* with references to Aldermaston, NPL and Winscale – thereby equating NPL with other centres whose activities do not enjoy whole-hearted public support (as with Porton Down above).

It is of course this type of journalism – known as ‘horror story’ writing – which is appalling. Such stories exaggerate, distort or falsify information in a way that makes captivating reading but, at the same time, undermines trust in the institutions concerned, particularly scientific ones.

In the present instance, the impact at NPL of such tabloid sensational scare mongering was dramatic:

- In the late evening (18th) prior to the Daily Express so called ‘revelations’, the media including the BBC and ITV television crews, besieged the NPL gates, presumably through some planned leak or tip off, to witness events at first hand.
- First thing in the morning of the 19th, Dr Paul Dean, Director NPL, and others were urgently summoned to Whitehall by Norman Tebbit, Secretary of State, to brief Kenneth Baker, the Minister directly responsible for the NPL, to respond to a private notice question tabled for that afternoon by Toby Jessel, the MP for Twickenham, in whose constituency the Laboratory was sited. A House of Lords question was also tabled on that day. The discussion is recorded in Hansard (January 19). Factual answers were given to the Daily Express allegations in order to reassure MPs, some of whom referred to levels of anxiety in their constituencies.

- At Kenneth Baker's request, as Minister for Information Technology, a public meeting was held involving local residents and other interested parties.
- The forthcoming Laboratory children's Christmas Party, normally held in late January, was cancelled.
- 'STOP MAKING ATOM BOMBS' was daubed on a library window facing a public road which crosses the Laboratory grounds.
- The impact of the whole episode was such that even property values in neighbouring streets fell, as illustrated in JAK's cartoon in the Evening Standard. *(Figure 2)*

"Of course, there's a slight radiation risk!"

Figure 2.

It took some months for the situation to return to normal. Once the public mind is infected with some irrational belief, it is indeed very hard to control.

HISTORY OF MEDICINE AND MEDICAL EDUCATION

Prof. Dr. Alfredo P. Buzzi[1] and Dr. Alfredo E. Buzzi[2]

"La science de la médicine, si elle en veut pas être rabaissée au rang de métier, doit s'occuper de son histoire et soigner le vieux monuments que le tems passées luis ont légués."

("The science of medicine if it is not to be lowered to the rang of a trade, must take care of its history, and of its old monuments, which are the legacy of its past times")
Émile Littré (1801-1881)

When the value of the study of medical history is considered, the majority of our colleagues it is nor interested at all, thinking that it is an occupation of old and retired physicians that investigated an amount of past events, many of them curious, absurd, or obsolete, or as a list of the errors and fantasies of our ancestors. All these considerations are taking into account with the limitations of being submerge in the past with no links at all with the progress of medicine or today's practice. Others are of the opinion that medical history is a specialty related with archaic libraries and museums, completely alien of the medical problems of today, and surely incapable to bring any support for research projects of the future.

Medical history is a subject of study very old, and at the same time quite recent. Until the beginning of the XIX century medicine of antiquity was seriously taking into account, for over 2000 years, Greek medical treaties were consulted as real authorities and trustable sources of information. This attitude toward the past of medicine was radically changed since the second half of the XIX century, when medical science produced advanced and discoveries as never has occurred before. As a consequence the past look sterile and devoid of teachings. History of medicine appears therefore as the history of the mistakes and fantasies of physicians of the past. To study the old authors looks as a waste of time. The best intellect were dedicated to clinical and laboratory research, and to the applications of the new instrumental methods to clinical practice

Medical history as a discipline is very young. The first institute of research on medical history in Europe was founded in 1905 in the University of Leipzig by Karl Sudhoff (1853-1938), and the first created in the USA was at the Johns Hopkins University (Baltimore) in 1929, due to the efforts of William Henry Welch (1850-1934). In the University of Buenos Aires the Chair of History of Medicine was created in 1936, due to the efforts of José Arce (1881-1968)

It would be a mistake to admit that medical history is of interest only to historians and philologists, and is devoid of value for physicians. As it was in the past medical history is medicine itself, and is part of its theories and practices. It is obvious that the physician can efficiently treat a patient with pneumonia or syphilis having not knowledge of medical historiography of this diseases. The only history that has to know is that of the patient. But in the moment that is necessary to plan the eradication of tuberculosis or venereal diseases, of the medical assistance of the underdevelopment human population in rural districts, in other words, when our efforts are directed not to isolated individual but to a group of men, then we need historical knowledge. The success or failure of our effort may depend not only on the magnitude of the human and material resources at our disposal, but of the correct appreciation of the economic, political, social and religious factors determining a particular situation, and this is and appreciation we can only arrived as a result of an historical analysis.

Medical history teaches us where we come from, where are we situated medically in the present moment, and in which direction we move. It is the compass guiding us to the future. For our work not to be erratic, to follow a well organized plan, we need the guide of history. In effect, it is not

[1] Emeritus Professor. School of Medicine, University of Buenos Aires.
[2] Subcommittee of History. Sociedad Argentina de Radiología.

accidental that the majority of the great medical leaders of the world were firmly convinced of the value of historical studies.
The most urgent problems of today, be it for the difficulties of its epidemic control as for the result of treatment, forced us to look to the past. The outbreak of AIDS syndrome in New York and San Francisco towards 1980 has a curious similarity with the outbreak of syphilis in Europe during the siege of Naples by the troops of Charles VIII of France (1470-1498) in December of 1498. Both affections were unknown until its outbreak. Both have a clear venereal origin, a serious course an even mortal if they are not treated, and both determined a drastic changed in the sexual behavior of the population.
In its causation different theories existed. The Scottish surgeon and biologist John Hunter (1728-1793) described the syphilitic chancre bearing his name, and trying to establish if syphilis an gonorrhea were the same disease, arrived at this erroneous conclusions, until Phillippe Ricord (1800-1889), in the middle of the XIX century recognized the differences of both affections fifty years before that Fritz Schaudinn (1871-1906) and Erich Hoffmann (1868-1959) identified the causative agent. In both diseases a defined geographical origin was postulated, America for syphilis and Africa for AIDS, as well as an animal reservoir, with posterior dissemination for an aberrant sexual patient or for trials for the development a vaccines for malaria.
It is pertinent to considered how medical history can be of help for the future project as important as medical sociology, epidemiology, professional practice, bioethics, and medical education.
The study of medical history is included in the curriculum of great number of medical schools in America and Europe. It is usually accepted that this study contributed to an harmonious formation of physicians, compensating limitations from specialization and sub-specialization in all the branches of medicine, and act as a bridge between scientific knowledge and medical humanities.
The historical study shows the development of medicine in an integral way, empathizing its continuity in time, as well as the recurrence of certain elements that characterize its theory and practice. Analyzing the changes that had occur in the medical ideas of the past, the student-physician can recognized the economic, political, philosophical and cultural forces that have structure medicine of today, as well what can be expected in the future, being the afford prepared to foresee the inevitable changes that will occur. Finally, development a senses of historical perspective and a healthy critical point of view the physician will be able to appreciate with equanimity the transient and ephemeral methods of diagnosis and treatment.
As a final conclusion we wish to postulate that medical history allows us to reconstructed the past, illuminated the present, and guided to the future. Arturo Castiglioni (1874-1953) a noted Italian medical historian, imagined history of medicine as the master road of our long voyage ("*la strada charact del nostro lungo camino*"), a compass to guide us in the dark and uncertain way of the future. The great Canadian physician William Osler (1849-1919), affirmed that "by the historical method alone can many problems in medicine be approached profitably." The Spanish medical historian Pedro Lain Entralgo (1908-2001) expressed that the intellectual formation of a physician is uncompleted if he is not capable of giving and historical reason of his knowledge. Without an adequate historical formation the physician can be a good technician in the traditional sense of this expression but not a real pathologist.-

BIBLIOGRAPHY

1.- Blake, J.B.: Education on the History of Medicine.. Hafner, New York, 1968
2.- Brain, R.: Doctors, past and present. Pitman, London, 1966
3.- Buzzi,A.: El médico del futuro. Simposio Roemmers. Buenos Aires, 1977
4.- Buzzi,A.: Evolución Histórica de la Medicina Clínica. Buenos Aires, 1968.
5.- Buzzi, A.: John Hunter y el Museo Anatómico del Royal College of Surgeons. Bol.Acad.Nac.Med., 74: 209, 1996
6.- Castiglioni, A.: Il Volto di Ippocrate. Unitas, Milano, 1925

7.- Gibson, W.C.: Creative Minds in Medicine. Thomas, Springfield, 1963
8.- Guthrie, D.: Whiter medical history? Medical History, 1: 307,1957
9.- Guthrie, D.: Janus in the doorway. Pitman, London, 1963
10.- Lain Entralgo, P.: Importancia de la historia de la medicina en la formación del charac. Orientación Médica, 10: 765, 1961
11.- Lichtenthaeler, C. : Histoire de la Médicine. Fayrd, Paris, 1978
12.- Osler, W.: Aphorisms. Schuman, New York, 1950
13.- Sigerist, H.E.: On the History of Medicine. MD Publications, New York, 1960
14.- Sigerist, H.E.: On the Sociology of Medicine. MD Publications, New York, 1960
15.- Thompson, D.: The present need for the study of the History of Medicine. In Cope, Z.: Sidelights on the History of Medicine, Butterworth, London, 1957

WILLIAM CROOKES: COVERT RESOURCES AND A MENTOR, 1871-81.

By the late
Derek R. Guttery.

Derived – during 1991-1998 – from primary sources including unpublished letters and laboratory notebooks in the Royal Institution and Science Museum/Imperial College and Cambridge University Libraries and from St. Pancras Parish Registers and Census enumerator's returns for 1861 and 1871.

WILLIAM CROOKES:

COVERT RESOURCES AND A MENTOR, 1871-81

Robert DeKosky opens a 1976 paper on William Crookes' "Fourth State of Matter" with the statement:

> William Crookes is a puzzle to historians of late-nineteenth century science. Despite his achievements we are forced to ask why he did not accomplish more.[3]

It is an interesting question but equally interesting is the question that prompts this paper – how did he accomplish so much?

Why some scientists become both prolific and successful is a question with both historical and historical dimensions. Among the former are a number of cultural aspects rarely studied by historians. They include the nature of childhood experience, family attitudes, mentoring, and the existence of intellectual and practical support networks in adulthood.[4] All are important, but how they contribute to individual success varies with time and context

While the history of science has acquired a more socio-cultural aspect during recent years, the focus has been largely on the acceptance of new scientific ideas and practices and on the rejection of old ones or, in other words, how truth and practice are arbitrated. Historical explanation has moved from the empirical towards a form of the social. J.R.R.Christie defined the new perspective in an essay derived from a one-day meeting "The Big Picture" held at the Science Museum during 1991 –

> . . . the registration of science as power indicates a shift from an epistemological to a performative conception, from an epistemological or methodological view of valid cognitive expression to a socio-logical view of cognitive action.[5]

This focus on the knowledge-power nexus has yielded new insights into how scientists behave but in so far as individual success is concerned, the historiographical emphasis has been on advancement within professions and learned societies. In other words, competition among scientists has been stressed at the expense of many cultural circumstances that produce scientists in the first place and make that science possible. The historiographical focus has been on a later stage in the process, namely on the legitimation of new knowledge. Recent work on the laboratory or workplace, while widening the historian's focus, has similarly tended to emphasise the function of the laboratory and the interests it serves.[6]

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3 Robert DeKosky, "William Crookes and the fourth state of matter", *Isis* (1976), **67**, 36. In particular, DeKosky had in mind the discovery of X-rays and the identification of the electron.

4 Two recent studies of support network are those relating to "invisible technicians" in Sapin's *A Social History of Truth* and the detailing of Charles Darwin's many dependencies by Janet Browne. These throw much light on the role of assistance in the social and moral economy of science in their respective periods. Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth-England*, Chicago, 1994, ch.8, and "Who is Robert Hooke?", in *Robert Hooke: New Studies* (ed. M. Hunter and S. Schaffer), Wolfeboro, NH, 1989; Janet Browne, *Charles Darwin: Voyaging*, London, 1995

5 J.R.R. Christie, "Aurora, Nemesis and Clio", *BJHS* (1993), **26**, 404

6 See, for example, Frank A.J.L.James (ed.), *The Development of the Laboratory: Essays on the Place of Experiment in Industrial Civilisation,* London, 1989. An exception to my claim is the essay by

In a manner consistent with Christie's remark, the stress has been on how knowledge is produced in the laboratory and how this relates to larger political or professional interests. The emphasis on professional competition, and on science politics broadly construed, has certainly proved very fruitful, but it has obscured (or at least characterize) the social realities of human interdependence, many of the exchange of money, goods and services that underlie individual success, and those individual actions that are consistent with, but not reducible to, the dominant normative constraints of a particular historical period.

Some themes of interdependence are addressed in this paper. Aspects of Crookes' work in the decade 1871-81 will be discussed in the context of his relationship with family members, a principal assistant, other employees and a mentor. While it is not intended to make any general claims about Victorian support systems on the basis of one decade in one individual's life, it is assumed that since support is necessary, though not sufficient, for success, such a study is worth while and may provide clues to more general phenomena. Except in its success, Crookes' career was not unusual among those of his contemporaries. Like many it was freelance and had components of entrepreneurship, teaching, writing, government contracts and private research. When science in the modern period is discussed, the entrepreneurial, industrial and government settings in which much of it took place cannot be ignored. This is true of Crookes' work, too, though it was expertise in the laboratory that brought him respect and a voice in the scientific community. While this paper is intended principally as a study of invisible resources, much of what follows has to do with how laboratory work was shared.

CROOKES: FAMILY SUPPORT AND PRE-1871 BACKGROUND

William Crookes, born in 1832, was the eldest of sixteen children of his father's second marriage. He had six older half-brothers and sisters.[7] This large family was well supported by the father, Joseph Crookes, who, having apprenticed, left Yorkshire in his late 'teens and found work in London with a Regent Street tailor. He later had a very successful business of his own. In addition to premises over his Regent Street shop, Joseph Crookes bought a house at the edge of Regent's Park (Park Village East) and a farmhouse near Hammersmith, which was then in the country. The family members moved between the three homes. William Crookes had a few years of formal schooling but there are also other points about his early life, his family and childhood, worth mentioning. The family was well acquainted with people in the publishing and book trade. Crookes' aunt was married to a Regent Street bookseller and his eldest half-brother and another brother entered the bookselling business and had connections with publishers. Later

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David Gooding, "History in the Laboratory: can we tell what really went on?", ibid, 63-81. Gooding goes beyond the official accounts of experiments (performed by Faraday and Herschel). By examining notebooks and attempting to reproduce experiments under historical conditions, he gives new insights into the nature of Faraday's experiments and the laboratory culture in which they were performed. See also David Gooding, Trevor Pinch and Simon Schaffer (eds.), *The Uses of Experiment: studies in the Natural Sciences C*ambridge, 1989, and Bruno Latour and Steve Woolgar, *Laboratory Life: the Construction of Scientific Facts*, Princeton, N.J., 1986, though here the emphasis is mainly on the legitimation of facts.

7 E.E. Fournier D'Albe, *The Life of Sir William Crookes,* London, 1923. See also W.H.Brock, "William Crookes", *DSB*, iii, 474-82, and William A. Tilden, *Famous Chemists: the Men and their Work,* Freeport, NY, 1921. Tilden's chapter "William Crookes", is an expanded version of the obituary notice that he wrote for *Proceedings of the Royal Society,* **96A** (1920), i-ix.

these connections became important; for example, his father and two brothers helped Crookes in obtaining the copyright for the *Chemical Gazette* and in the founding of *Chemical News*.[8] His father maintained an interest in Crookes' business affairs, at least until the late 1870s.[9]

In such a large family it is not surprising that the children were often left to their own devices, and Crookes, in common with many other successful nineteenth-century scientists, appears, as a child, to have had a relatively unmediated access to the natural world. In Crookes' case, time was spent in the country and in a corner of the house where he taught himself some chemistry; "From my earliest recollections I was always trying experiments and reading any book of science I could find."[10] This self-motivating interest in natural philosophy and chemistry was of a well-established gentlemanly pattern, even though Crookes was not born into a gentlemanly class.[11] It is quite possible, however, that in the early 1840s a lack of formal schooling was still an advantage to someone entering the field of chemical science, and that William Tilden's claim, that "Crookes' whole scientific career is interesting . . . as illustrating the fact that to a man of genius the character of his early education has but little influence on his achievements", is misguided.[12] Indeed, it is likely that when, at the age of sixteen, Crookes entered the Royal College of Chemistry in the turbulent year of 1848, he had a potential in part due to natural ability and in part the result of a particular childhood culture in which there was much freedom from supervision but no neglect.

Crookes was an excellent student but was not drawn to the experimental organic chemistry that A. W. Hofmann was promoting at the college; he was more interested in those areas where chemistry meets physics and, like so many others, was taken with Faraday's lectures at the Royal Institution.[13] According to William Brock he may have consciously modeled himself on Faraday who, by the early 1850s, had taken note of Crookes and had introduced him to Charles Wheatstone. Crookes also met George Stokes around this time.[14] Both men became important patrons, but also important to Crookes' career were the many contacts he made through the

8 Fournier D'Albe, op. cit. (5), 47-53. The brothers were associated with Griffin, Bohn and Co., the first publishers of *Chemical News*. The publisher managed the financial side of the business until Crookes later took over. See also William H. Brock, "The *Chemical News,* 1859-1932*", Bulletin of the History of Chemistry* (1992), **12**, 30-5.

9 It is not clear exactly how much money Crookes' father contributed towards his later house purchase, the construction and fitting of the attached private laboratory (modest at first) and the various business ventures. Fournier D'Albe, op. cit. (5), is vague on this, simply noting that help was given. Joseph Crookes was clearly very involved in the 1860s when his son attempted to promote a gold-refining process in South America.

10 Fournier D'Albe, op. cit., (5), 16. This is quoted from a letter to Francis Galton who was interested in the genesis of talent. It is an interesting cultural fact that chemists liked to portray themselves as living near the edge. In the same letter Crookes wrote of "generating smells and destroying furniture".

11 For a discussion of the themes of knowledge and gentility in early modern England, see Steven Shapin, '"A Scholar and a Gentleman": the problematic identity of the scientific practitioner in early modern England", *History of Science* (1991), **29**, 279-327.

12 Tilden, op. cit. (5), 270.

13 Fournier D.Albe, op. cit (5), 22-3

14 Brock states, op. cit (5), 474, that Crookes says he met Stokes in 1850 at one of Mr Barlow's "At Homes", where he was introduced by his host. See Fournier D'Albe, op. cit (5), 399.

college.[15] There, he started to build a network from a very early age. This was not unusual; most of those who entered the Royal College of Chemistry in the mid-nineteenth century saw themselves as brothers in a new enterprise and were part of a fraternal culture based on communal and somewhat competitive laboratory work, on clubs, and on outdoor and evening activities. Practical science teaching was a new and shaky enterprise when Crookes entered the college. But it had its supporters among medical men, agricultural land owners and industrialists.[16] Senior scientists who wanted it to succeed were willing patrons to the young and promising, though, no doubt, they had other motives also. Patronage is a complex business.

Charles Wheatstone, an early mentor, was impressed by Crookes' attempts at photographing some astronomical phenomena and encouraged him to take up photography on leaving the college. Wheatstone also helped Crookes to obtain a Royal Society grant of £20 to enlarge some photographs he had taken of the moon; these created a stir when exhibited at the Crystal Palace at Sydenham. This was the first of a number of grants Crookes obtained. However, grant money can only have been a small component of his later research budget. Photography was a field in which he found it possible to make new scientific discoveries while at the same time earning a living.[17] He early showed the entrepreneurial spirit that can be seen also in his father and in other members of his large family. He did try for a few college, university and public positions but was not successful; very few chemist of his generation were.[18] Important teaching, research or industrial posts were scarce and, as already mentioned, life as a freelance entrepreneur was not uncommon.

By the 1870s Crookes had engaged in a number of activities and was well known in the scientific community. Certain life-patterns had been set. In addition to building a network, he discovered early that in making a living, as well as in building a reputation, it was necessary to find and cultivate good assistants and employees. An early example of assistantship is that of Charles Greville Williams. Williams had been a chemical assistant to professors in both Glasgow and Edinburgh, and for a few years, in the late 1850s, had been a chemistry lecturer at the Normal College in Swansea. He was the author of a handbook of chemical manipulation.[19] Like Crookes he was building a freelance career – later, he became an employee in the chemical industry and a small-time entrepreneur. He was three years older than Crookes and, in the late 1850s, had the greater reputation.[20]

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15 For a discussion of the social climate at the Royal College of Chemistry, see Gerrylynn Roberts, "The Royal College of Chemistry (1845-1853): A Social History of Chemistry in Early Victorian England", PhD dissertation, The John Hopkins University, Baltimore, 1973, 342-55.

16 Roberts, op. cit (13), 12-13 and 53-90.

17 See Fournier D'Albe, op. cit (5), ch.5, for an account of this period and of Crookes' work in photographic journalism; see p.35 for the Royal Society grant. Crookes was an excellent scientific photographer. He also kept a photographic record of apparatus and equipment used in his laboratory.

18 At the start of his career, in 1855, Crookes did spend one year as a science teacher at the College of Science, Chester, but by then he had already embarked on a variety of photography projects. In 1862 he gave a course of lectures with demonstrations to students of the Peckham Schools. See Fournier D'Albe, op. cit (5), 28 and 82

19 C. H. Greville Williams, *A Handbook of Chemical Manipulation*, London, 1857. For biographical details see an obituary by A. H. Church, *Proceedings of the Royal Society* (1911), **85**, pp.xvii-xx. Church was two years younger than Crookes and had also been a student at the Royal College of Chemistry. For a while he, too, was a close Crookes associate and a frequent contributor to *Chemical News* in its early days.

20 Williams was elected FRS in 1862, one year before Crookes.

But by the early 1860s his professional relationship with Crookes, as Frank James has noted, was very unequal. "Williams was effectively Crookes' research assistant rather than an equal collaborator in jointly conducted chemical research projects."[21] Letters, edited by James, show how Crookes cultivated the relationship by arranging to have apparatus made for Williams, while at the same time encouraging him to carry out research on thallium, the results of which Crookes could, and did, use in his own work. Williams received paid work from the *Chemical News*, and provided much copy for the journal (for example book reviewing, recording patents) in addition to getting several of his own articles published. It was not an entirely one-sided relationship but it was clearly to Crookes' advantage to cultivate it, as he did.[22]
Family support was integral to the success of Crookes' private laboratories and to his rise as a scientific gentleman. His first laboratory was one he built at the back of the house he purchased in 1861.[23] It was located not far from the family home at Regents Park. When he moved in, in addition to himself, the household consisted of his wife, mother-in-law, one child and some servants. By 1871 there were three live-in servants and five more children.[24] The business started, and continued, as something of a family economy with contributions from Crookes' wife Ellen, his mother-in-law, and later from his children.[25]

Other family members helped by sending work his way. For example, contracts for the analyses of coals, iron ores and pig iron came from his cousin, Charles Crookes, who was manager of the Coalbrookdale Company.[26] In addition to help from his family and household servants, he had a number of employees and possibly, in the mid 1860s, also an apprentice.[27]

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21 Frank A. H. L. James, "The Letters of William Crookes to Charles Hanson Greville Williams, 1861-2: the detection and isolation of thallium", *Ambix* (1981), **28**, 131-57, quotation on 133.

22 According to Fournier D'Albe, op. cit (5), 68, Crookes' right-hand man at the *Chemical News* at this time was W. T. Fewtrell.

23 He purchased the freehold for 20 Mornington Road, London (now Mornington Terrace), in 1861, though he had already been living there for about two years; see St.Pancras Parish Register, 1862. It is likely that some family money went towards the purchase. He stated in one letter to Angus Smith that he had some private income; Fournier D'Albe, op. cit (5), 90. Since the rates for 1862, £56 per annum, were the highest in Mornington Road, the house must have been among the largest in what was a professional middle-class neighbourhood (inferred from St. Pancras 1861 and 1871 census details). Crookes did not sell this house when he moved to Notting Hill in 1881 and owned it till his death.

24 1871 Census, St. Pancras Borough.

25 There are frequent references in letters indicating that his wife, Ellen, dealt with much of his correspondence, for example a letter to his son, Henry, in Fournier D'Albe, op. cit (5), 260. This letter also throws an interesting light on Crookes as a family man. He wrote lovingly about all the family members. Henry had been sent to Australia, partly for health reasons. Rayleigh makes reference to Ellen Crookes carrying out weighings in the laboratory. From the Crookes-Gimingham correspondence one has the impression that Crookes' mother-in-law, Elizabeth Humphrey, was responsible for some of the accounts and that at least three of his sons helped with experiments. Science Museum Library MS409; Letters to Charles Henry Gimingham, 1871-77 (hereafter SML, Letters). The family economy pattern is not unlike some described in Leonore Davidoff and Catherine Hall, *Family Fortunes: Men and Women of the English Middle Class, 1780-1850* , London, 1987, part 2.

26 Fournier D'Albe, op. cit (5), 45. This contract brought in about £20 per annum. According to Fournier D'Albe, ibid, 70, Crookes had a number of similar contracts but refused to put his name behind any promotion. Clearly this was prudent in someone wishing to make a name in science.

27 According to Fournier D'Albe, op. cit (5), 86, in 1864 Crookes negotiated with the father of a prospective apprentice, Henry Seward, a pupil at the Peckham Schools where Crookes had given some

CROOKES' CAREER: SOME SOCIAL ASPECTS

Crookes' career was long and varied. Historical evidence is fragmentary and comes from a number of different sources, but none the less it gives a complex and vivid impression of the many factors at work in the career's production. What is also interesting about Crookes is that while many of the trappings of success came his way, namely public recognition, FRS in 1863, membership of the Athenaeum in 1882, membership of the Philosophical Club of the Royal Society in 1889, a knighthood in 1897, the Order of Merit in 1910, the presidencies of various learned and professional societies, including, in his eighties, the presidency of the Royal Society, one has the impression (though hard to document) that much of this was grudgingly given by a scientific establishment forced to recognize the brilliance of his many experimental investigations.[28] Perhaps this was because Crookes was not a typical self-improver (though he was undoubtedly a self-helper).[29] Some of his contemporaries who came from similar unprivileged backgrounds, Thomas Huxley and John Tyndall, for example, *were* self-improvers and were more quickly, and with less scientific accomplishment to show for it, absorbed into the professional community. Unlike them Crookes did not educate himself in a manner that would have allowed him to absorb more easily the conventions of a class whose approval could help in social and career advancement.[30] Although Shaplin's model of gentlemanly authority can be applied even to the mid-nineteenth century, Crookes was able to rise to the top despite his poor general education, despite his life-long business activities from which his science cannot be divorced, and despite the fact that he made only few concessions to his social superiors. It is not my purpose to enter a philosophical debate here, but one could make a case that Crookes' experiments gave the science of his time an epistemic shove. One could also make a case for a shift in the nature of scientific authority in the late Victorian period: that it no longer resided so clearly with the governing class and that the scientific world was becoming more meritocratic. But, whatever the case, the existing scientific leaders did have to be convinced, did have to take the new on board and did have to signify its acceptance. In the business of getting his new data before the public, Crookes, as will be shown, had a suitable mentor in George Stokes.

It is interesting further to consider why Crookes sought success within the scientific profession over and above success in business. Clearly this relates to a broader aspect of British culture. Nineteenth-century social commentators such as Carlyle, Ruskin, Arnold and Morris were very critical of the business ethos, and their attitudes linger today. Business profits were often used to

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chemistry instructions. I do not know whether the boy actually became Crookes' apprentice, but in a letter Crookes mentions a three-year term at £500 per year.

28 There are many negative comments about Crookes in the published and archival material from this period. Oliver Lodge's nuanced foreword to Fournier D'Albe's biography, op. cit. (5), is an example.

29 A photograph, taken later in life in his Notting Hill house, shows Crookes seated in his fairly large library. This was a working, not a self-improving, library and was situated next to his laboratory. The photograph was reproduced by Lord Rayleigh and shown during his presidential address to the Physical Society in 1936. R. J. Strutt, "Some reminiscences of scientific workers of the past generation, and their surroundings", *Proceedings of the Physical Society* (1936), **48**, 217-46.

30 Crookes, as a young man, may have felt ill at ease in the gentlemanly and club culture of early nineteenth century élite science. He did not, for example, take up many of the dinner and speaking invitations that came his way after the thallium discovery, and the reason cannot simply have been, as Fournier D'Albe put it, that Crookes needed to earn a living for his growing family. Others might have seen the social route as having professional and financial potential. Fournier D'Albe, op. cit. (5), 65.

buy a gentrified life style or to ease the paths of children into professional occupations.[31] As will be mentioned, Crookes' father helped him in both these ways, while at the same time encouraging his entrepreneurial ventures. Moreover, Crookes was a student at the Royal College of Chemistry for a relatively long time (four years) and would thus have been well exposed to an ideology that place pure science above applied. A. W. Hofmann, the professor at the Royal College, while promoting chemistry through its applications, believed, as did so many other eminent scientists of the period, that a life engaged in pure scientific research was a noble one.[32] This is not to say that Crookes viewed his later business activities as a means only to an income with which to finance a private laboratory. He was proud of the business success he did have and sought even more. He also had many business friends. But ambition, probably fuelled by the ethos he had absorbed at the college, led him in another direction.

GEORGE GABRIEL STOKES: MENTOR

George Gabriel Stokes (1819-1903) came from the Anglo-Irish gentry; his father was rector of Skreen and many of his family were associated with the Church of Ireland.[33] He was a student at Pembroke College, Cambridge, and was a wrangler and first Smith's prizeman. He became a fellow of the college and, in 1849, Lucasian Professor. Important contributions to the *Cambridge Mathematical Journal,* under the editorship of his friend William Thomson, had, by the 1850s, made him well known.[34] But the professorship did not pay well and Stokes spent time in London during the 1850s teaching at the Royal School of Mines amongst other income-generating ventures. He first met Crookes in 1850, and in 1854 began his long secretaryship of the Royal Society. In 1856 a correspondence with Crookes began that was to last forty-five years. It is clear, from the collection in Cambridge University Library, that Stokes was a major letter writer (or, at least, a major letter recipient) but especially interesting to note is that much of that scientific correspondence is with chemists, especially those with physical chemistry interests.[35] Stokes had an early interest in fluoresence and in flame spectra; he translated some of Bunsen and Kirchoff's early papers, and it was on spectroscopic matters that his correspondence with Croques began. Crookes, like others at this time, asked Stokes to identify some spectral lines for him.[36]

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31 For a discussion of these themes, see M. J. Weiner, *English Culture and the Decline of the Industrial Spirit*, Cambridge, 1981.

32 Hofmann's views can be read from his annual reports to the Royal College. See Imperial College of Science, Technology and Medical Archives: Royal College of Chemistry, Minutes of the Annual General Meetings, 1846-53. See also Robert Bud and Gerrylynn K. Roberts, *Science versus Practice: Chemistry in Victorian Britain*, Manchester, 1984, 24-5, for a discussion of the social divide in metropolitan chemistry during the nineteenth century.

33 *DNB*, Second Supplement, iii; *DSB*, xiii, 74.

34 For details of the journal, see Crosbie Smith and M. Norton Wise, *Energy and Empire: A Biographical Study of Lord Kelvin*, Cambridge, 1989, 174-92.

35 For example, he had lengthy correspondence with F. A. Abel, Henry Armstrong, Heinrich Debus, Warren de La Rue, Henry Roscoe, James Dewar and Arthur Smithels. The last of these is interesting, and while it begins only in the 1890s, it starts, as did the correspondence with Crookes, much earlier, with flame spectroscopy. Cambridge University Library (CUL), Correspondence of George Gabriel Stokes (catalogue, ed. David B. Wilson) Add. MSS 7656. According to Andrew Warwick (personal communication) Stokes was unusual among Cambridge mathematical physicists of the period in engaging in some experimental work.

36 See Joseph Larmour, *Memoirs and Correspondence of the Late Sir George Gabriel Stokes,* 2 vols., Cambridge, 1907, ii, 363; Stokes to Crookes, 2 March 1856.

David Wilson has discussed this correspondence and notes that "Stokes' dominant role can be seen repeatedly.[37] Wilson implies an intellectually dominant role that is perhaps too sweeping a claim, and one that demonstrates a bias towards the mathematical and theoretical. Crookes' intellectual abilities were considerable but different from Stokes'; highly creative and of a kind able to invent and perform many ingenious experiments to test a wide variety of ideas. While Crookes was, and always had been, characterized as a brilliant experimentalist, Wilson is not alone in ranking the mathematical Stokes more highly. Certainly this Oxbridge hierarchical bias was shared by many of Stokes and Crookes' scientific contemporaries. However, it is surely better to accept that there exist different aesthetics. This allows one to surmise that, intellectually, the exchange between the two men was fairly even; perhaps, as I will suggest below, even slightly more to Stokes' advantage. Why else would the correspondence have lasted as long, especially since the two do not appear to have been close friends ? It is the case, however, that in the decade to be examined here, Stokes held the dominant position both socially and professionally. In the 1870s, especially important to Crookes was that, as Secretary to the Royal Society, Stokes was gatekeeper to publication in the country's most prestigious scientific journals. (He was editor of the *Philosophical Transactions.*) Crookes' psychical research was not allowed through the gate and this rebuff could have ended the correspondence, but Stokes was polite in his refusals and by 1873 was obviously interested in, and wanted a part of, Crookes' new research; the correspondence picked up. By that time Crookes had been pursuing a number of interesting ideas in his laboratory, following an observation, made while working on the atomic weight of thallium, that objects weighed in a partial vacuum appeared lighter when heated.[38] Unfortunately, the earlier extant laboratory notebooks on this work date only from July 1875, but some earlier correspondence between Crookes and Stokes and between Crookes and his assistant Charles Gimingham, survives. It throws some light on what was done in the early 1870s.

CHARLES HENRY GIMINGHAM: ASSISTANT

Charles Gimingham began as Crookes' assistant in 1870. He was sixteen years old and had been a pupil at the city of London School.[39] It is clear from letters and laboratory notes that there were some other employees during this period of employment, which lasted until early 1882. [40] But in what follows I will discuss mainly the roles of Stokes, Gimingham and Crookes. The aim is to understand better the genesis of good science; that it happens to be largely radiometer science is a historical accident. It is well to point out however, that in the very same period much else was going on in Crookes' life and that it was his assistant who largely ran the laboratory. Running *Chemical News* was a major concern and the *Quarterly Journal of Science* a minor one. At the beginning of the period Crookes published three books and had just returned from an eclipse

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37 David B. Wilson, *Kelvin and Stokes: A Comparative Study in Victorian Physics*, Bristol, 1897, 197.

38 W. Crookes, "On the atomic weight of thallium", *Philosophical Transactions of the Royal Society* (1873), **163**, 277.

39 Obituary notice for Charles Henry Gimingham, *Electrician*, XXV (1890), 625. (3 October)

40 Casual mention is made of two women glass-blowers employed from some time in 1881, the time when Crookes became seriously interested in electric lighting. The only one to be named was "Miss Tribling [who] made 24 lamp cases in 4 hours using up three cases of French Glass." Royal Institution, London, Laboratory Notebook, vol. VI, 1 June 1881 – 15 July 1884, entry for 8 March 1882. Some other employees will be mentioned below.

expedition.[41] From 1871 to 1880 he was a director of the Native Guano Company and was actively engaged in developing sewage treatment plants and in promoting them. It is clear that this was the source of much of his income during the 1870s.[42] A business to which he was less committed, but which did take up some time, was the Alzarine and Anthracene Company of which he was also a director. In 1866 he promoted Wilde's magneto-electric machine and later worked with business contacts in France in the promotion of electricity generation for lighting purposes. Roughly from 1876 onwards he became very interested in the manufacture of light bulbs and experimented with various filaments.[43] From 1877 Crookes and Gimingham experimented with gold-leaf electroscopes, the telephone and with the electrical wiring of the house. Indeed, Gimingham had a role in most of the above activities and also in one that must have occupied much time in the first half of the 1870s, research into spiritualist phenomena.

The City of London School, where Gimingham had been educated, included chemistry instruction in its curriculum and, at this period, many of its students went on to the Royal College of Chemistry.[44] Gimingham instead went straight into Crookes' employment and was probably selected because of talent in chemistry shown at school.[45] By late 1871 Gimingham was eighteen years old and had been in Crookes' employment for almost two years. As should become clear below, Crookes took care in training Gimingham and treated him kindly. This care and attention paid off very well.

SCIENTIFIC WORK: WHO DID WHAT, 1871-81

In September 1871, Crookes, just returned from a holiday, wrote a note addressed to "Charlie" hoping that he too had a good holiday and that there was some new work to do on sewerage; "I am in the hopes of putting something remunerative in your way with it.[46] By October,

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41 W. Crookes, *On the Manufacture of Beet-Root Sugar in England and Ireland,* London, 1870; *Select Methods in Chemical Analysis (Chiefly Inorganic)*, London, 1871; and a translation of R. Wagner, *A Handbook of Chemical Technology,* London, 1871. Crookes published several other books before, during and after the 1870s. For the eclipse expedition see Fournier D'Albe, op. cit (5), ch.11.

42 As a member of the board and as chemical adviser, Crookes earned £200 per year. In addition he was [paid for on-site work, roughly £1,000 per year. The firm also bought some of his patents, including one for a "carbolic sulphite deodoriser" for £2,200. Later in the decade he spent roughly the same amount of money to buy the English patent rights for a French sewage treatment method from Georges Fournier (Fournier D'Albe, op. cit. (5), 268). Further, Crookes ran his own firm, Crookes & Co., for a few months during the 1870s; this promoted machinery for the digestion of animal refuse but proved unprofitable in the long run (ibid., 257-8) *Chemical News* brought Crookes an income of about £400 per year. Later (post-1880) Crookes' income was about £4,000 per year (ibid., 378). It would appear that his income in the 1870s was roughly the same.

43 For details of the Native Guanao Company see Fournier D'Albe, op. cit. (5), ch.14. For a while this was successful, with several installations that Crookes supervised. For Crookes' electrical interests see ibid., 291and *passim.* In the 1880s Crookes became a director of the Electric Light and Power Company. He took out his first patent on a light bulb in 1881 when he established a lamp works in Battersea and made his son, Henry, manager. Unable to hold his own in this highly competitive field, he later sold out and also sold his patents (ibid., 303-7).

44 Jonathan Bentley, "History of the School of Chemistry at the Royal College of Science and its Predecessors during the Nineteenth Century", Chemistry Part II thesis, University of Oxford, 1962, 31-3.

45 There is no direct evidence for this but Fournier D'Albe, op. cit (5), 85 shows how careful Crookes was in selecting an apprentice a few years earlier.

46 SML, Letters, 13 September 1871, from 20 Mornington Road, London.

Gimingham was also at work on vacua and not for the first time. He received instructions every few days from Crookes, who was away in Manchester on a business trip. For example, "I am sorry the 'Sprengel' does not work well – try patching up the top with grease . . . you ought to be able to get a vacuum easily within . . . 1/100th inch in that way."[47] Crookes was a good draughtsman and his instructions often included sketches of what he wanted made. The following instructions on mercury distillation (the Sprengel pump needed mercury) one can only hope were salutary; they are a reminder of how self-sufficient such laboratories had to be:

> I have two iron retorts for the purpose . . . clear out well and be particular to get the joint smooth so that the head fits nicely. Then put the mercury in so as to about ¼ fill it. Cover it with a layer of lime, if you have any . . . Cover the joint well with clay or plaster . . . Distil over a fire in an *open grate* (the store room will be best) and remember that a great flame is wanted. Put a little coal at the bottom but feed the fire constantly during the operation with little bits of firewood to get a great blaze all around the retort and licking over the head or the mercury will condense and run back. You will probable have to burn two or three bundles of firewood. Condense by letting the end of the iron pipe dip about half an inch into water in a basin on the floor . . . Don't risk breathing any vapour . . . If unfortunately, you detect a leakage, put the fire out, open the window, leave the room and close the door. Don't open until the retort is cool . . . The Sprengel will have to be cleaned if dirt from the mercury has got in. Don't be disheartened. Very sincerely, yours, W. Crookes.[48]

Fairly detailed written instruction appears quite frequently in the correspondence and in the laboratory notebooks, where messages back and forth are recorded. Even when Crookes was in London he often went to the laboratory only late in the evening and so had to leave notes for his assistant. At the time of the above instructions, Gimingham was trying to get a good vacuum and Crookes may have believed he was within reach of a perfect one:

> I wish I knew whether you are trying these experiments with the perfect vacuum, assuming it to be so air currents cannot exist. The effect of heat on some crystals is to develop pyro-electricity – a tourmaline is a perfect example . . . Mr Spence has given me some magnificent crystals of alum which I have sent . . . Open them *very* carefully. I do not want their edges chipped.[49]

Further instructions for observing crystals in vacua follow and for testing them for pyro-electricity. "Try your hand at a vacuum tube for an induction coil. You can be passing the current whilst the mercury is running so as to see the best time to seal it up."[50] But these were not the only kind of instructions Gimingham received. He had to respond to some of Crookes' mail and to forward some of it. He had to prepare specimens or equipment and send them to Crookes

47 SML, Letters, 8 October 1871, Manchester. Reference to the "Sprengel" is to the type of mercury pump used. Iinvented by Herman Sprengel in 1865, it worked by allowing mercury to fall down tubes, capturing air between drops. For further details, and for how it was used, see Robert DeKosky, "William Crookes and the quest for the absolute vacuum in the 1870s", *Annals of Science* (1983), **40**, 1-18.

48 SML, Letters, 10 October 1871, Manchester.

49 SML, Letters, 19 October 1871, Manchester.

50 SML, Letters, 13 October 1871, Manchester.

for showing. He had to settle accounts and send receipts for ground rents and perform other similar tasks. Sometimes he was asked to hand over bills to Mrs Humphreys.[51] Crookes certainly piled on the work but he was responsive to Gimingham's needs and gave him time off when requested. Of course he should take time off to help at home, "we shall be pleased to hear that your mam and the baby are getting on well", and "Dear Charlie, you can take two or three days at the beginning of next week to run down to Suffolk as you wish. I hope you enjoy yourself, although it is getting rather cold for the country."[52]

Early in 1872, Crookes was unwell, "I rather suspect (and my doctor confirms this) that I have had a touch of sewer poisoning and I wonder if a good dose of ABC would do me good". But he notes that he has "two good lieutenants" working for him.[53] Later that year he took a three month business trip to Paris; part of the time was spent supervising the construction of a sewer purification installation.[54] While he was away, Gimingham was busy doing experiments that were later described by Crookes in the first and second of his series of papers for the *Philosophical Transactions.*[55] On Crookes' instructions and, it would seem, using much initiative

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51 Mrs Humphreys was Crookes' mother-in-law. She appears to have had some role in ordering, and paying the bills of suppliers – at least while Crookes was away. There are several references to this. See, for example, SML, Letters, 5 November 1872, Paris. The reference to ground rents here and elsewhere suggests that Crookes was a landlord.

52 SML, Letters, 18 October 1871, Manchester, and 27 September 1872, Paris. I think the new baby followed in his brother's footsteps and became a glass blower with Edison and Swan. There are references to a Mr E. Gimingham having come from Edison and Swan to do glass-blowing for James Dewar at the Royal Institution. Also, William J. Green, an assistant at the Royal Institution, in a letter to Lord Rayleigh, 2 May, 1940, mentions Mr E. Gimingham as being a "hale old man" with a business in Diverton. See Royal Institution, Dewar Papers, DE 9/3/2 and DE 16/2/38.

53 SML, Letters, 27 January 1872, Mornington Road. The ABC (alum, blood, charcoal and clay) process, developed in the 1860s, was designed to treat sewerage and convert it to saleable manure. The process had been invented by W. C. Sillar; see Fournier D'Albe, op. cit (5), 257-9. Crookes had to deal with several disputes over the quality and safety of the manure. The reference to a second "lieutenant" is one of several references to other workers. This one was called Mr Slater. By April 1872, Crookes was using a monogrammed letterhead. It consisted of a cross above which was an elephant "quarterly . . . charged with two crosses pattées . . . resting the dexter forefoot on a prism proper". His initials are entwined around the cross on which is inscribed the punning motto "*ubi crux ibi lux".* Later, when knighted in 1897, Crookes used this as his heraldic crest. It would be good to know what his peers thought of it. Crookes appears to have been very careful of his reputation so one must conclude that "respectable" taste has changed. Though perhaps not – in *Our Mutual Friend*, Charles Dickens made fun of the Veneerings for a similar vanity; and Crookes' involvement with spritualism caused a wag to refer to *ubi Crookes ibi Spooks* (J.J.Thomson, *Recollections and Reflections,* London 1936, 383).

54 SML, Letters, 7 November 1872, Paris. Crookes was happy with the installation. "The process works very nicely and the water is very good. Fish are living nicely in the third or fourth trial. On Wednesday we begin to receive official visitors."

55 W. Crookes, "On attraction and repulsion resulting from radiation", *Philosophical Transactions* (1874), **164**, 501-27. A version of the paper titled "On the action of heat on gravitating masses" had already been read at the Royal Society, 11 December 1873, and was published in *Proceedings of the Royal Society* (1873), **22.** It was later summarised and serialised by Crookes in *Chemical News*. He did this for all the papers in the series. For a full account of Crookes' work, see the papers published in *Phil. Trans.* between 1874 and 1881. These papers are remarkable for their fine and very detailed description of experimental procedure. Crookes was undoubtedly making a statement about what it takes to do the kind of vacuum studies he was engaged in. It is possible to read his very good descriptions of the finesse needed, as a not- too-subtle message telling others that the field was so difficult they would be wise to stay away. Another interesting point, not acknowledged by earlier historians, is that Crookes and Gimingham of his own, Gimingham experimented with ways in which the effect of heat on objects enclosed in evacuated tubes could be measured.[56] From Paris, Crookes wrote: "the design for the neutral point apparatus seems good" but, to see the needles better, "can you fit up a series of reflectors for light to be thrown on the index and lenses to magnify it so that you only have to put your eye to an eyepiece to see the needle and its movements". Gimingham was asked to experiment with cement for sealing-in observation windows and to develop a vacuum apparatus with as few joints as possible. And, "for needles try glass threads with pith ball terminals, silk sewing thread stiffened with shellac, ditto cotton thread. Keep one of the apparatus for illustration and showing and take very full notes of all you do with them."[57] Crookes gave instructions for seemingly endless permutations of the apparatus and for changes in initial laboratory conditions (including performing the experiments in different rooms). The basic apparatus mentioned above, once developed, consisted of a small balance suspended by various fibres and with weights (usually discs) made of a variety of materials. This was enclosed in a vacuum; torsion in the fibre, induced by heat on the weight, was measured by a ray of light reflected from a mirror onto a scale. But Gimingham, as before, also had a number of unrelated tasks; for example, he had to prepare and send all kinds of things to Paris, and build a demonstration model for sewage treatment from instructions given from afar and by looking at earlier models in Crookes' photographic archive.[58]

The vacuum experiments continued into 1873. Crookes speculated over what was going on.[59] But, as in 1872, he was often away from London and appears to have spent little time in the

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were already experimenting with the torsion balance in 1872. Crookes did not mention this new apparatus in print until the submission of an abstract to the *Proc. Roy. Soc.,* 20 March 1875. The 1874 *Phil. Trans.* paper described a series of experiments in which heat repelled an object suspended at the end of a regular balance beam. In his second paper in the series, Crookes does not mention that he had discarded the traditional balance form of apparatus even before his first paper was read to the Royal Society and that some early versions of the new apparatus had been displayed on 11 December 1873. See paragraph 84 in W. Crookes "On repulsion resulting from radiation, Part II", *Phil. Trans.* (1875),**165**, 519-47. It is clear, however, that in these 1873 demonstrations, Crookes was holding much back..

56 Crookes' original vacuum balance was from Oertling and the weights from Johnson and Mathey were made of platinum and manipulated from outside the evacuated case. But by this time (1872) very simple balances that could be enclosed in blown tubes had been devised and were being improved on – as were appropriate measuring procedures.

57 SML, Letters, 27 September and 5 November 1872, Paris. The "neutral point" was the point (in evacuation) at which change in the direction of movement in the pith balls (an other objects), occurred when hot (or cold) objects both within and without the evacuated tubes, were brought close (see published papers for details). Crookes obviously wanted to keep the details to himself at this time. In a letter from Paris, dated 3 November, he wrote that Huggins wanted to see the Sprengel pump but "don't tell him too much about the neutral points and repulsion by heat experiments". William Huggins was a wealthy brewer, an amateur astronomer, a vice-president of the Royal Society at this time, and had taken part in some of Crookes' spiritualist activities.

58 SML, Letters, 9 October 1872, Paris.

59 Crookes' speculations and those of others have been widely discussed in the literature. See, for example, DeKosky, op. cit. (45). It is clear that Crookes did a literature search because he began his own series of papers with a discussion of historically related precedents, including the work of Fresnel and of the Rev. A. Bennett, FRS, whose magnetism experiments of the 1790s appear to have been very suggestive methodologically. Because he believed he had a good vacuum, Crookes speculated along two lines. First, that heat might affect the gravitational force and secondly, that heat had a direct mechanical effect on the weights (pith balls, or whatever). He and Gimingham also early experimented with spring balances because Crookes thought beams might expand with heat, but they gave these up as impractical.

laboratory. The Native Guano Company occupied much of his time and he made trips to Birmingham and several to Leeds, where he looked for suitable shale for the various sewer works then being built.[60] Meanwhile, Gimingham was puzzled by various anomalies in the experimental observations. Crookes advised him from afar, suggesting more and more permutations all the while "confident . . . that we shall find a theory to fit the facts".[61] They both took holidays in August. Crookes went with his family to Jersey from where he wrote a friendly letter to "My Dear Charlie", noting that he had not been in the "laby" much before he left because he was busy writing his paper (presumably the one received by the Royal Society on 12 August) and getting out a new patent.[62]

This paper was important in Crookes' future experimental work. In June 1872 Crookes wrote to Stokes notifying him of the thallium atomic weight paper that he wanted published by the Royal Society.[63] Nine months later he wrote twice, the first letter very ingratiating, thanking him for some pre-publication comments. He wrote that had he known Stokes was interested in what he was doing (which he had doubted, given their difficulties over the papers on physic research) he would have sent him an earlier proof. He thanked Stokes for some mathematical help, though given the gravimetric nature of the work it is not clear what this would have been, and said he had also had help from one of De Morgan's assistants. He informed Stokes that he had rewritten certain passages that Stokes had found "obscure" and had replaced "quantity" with "volume" and distinguished "weight" from "mass".[64] From this, and other evidence, it is clear that Stokes was a good and conscientious editor. He was also clearly happy to make amends but had not yet been informed fully of what Crookes and Gimingham were then doing. One can only surmise that Crookes was being careful. The correspondence picks up on another topic. Stokes wanted evidence for Prout's hypothesis and requested information on the atomic weights of some of the rare earths. Crookes gave him much detailed information including references, and a copy of that part of his book on analytical methods that dealt with the rare earths.[65] Stokes became aware of the vacuum work, but not the extent of it, when Crookes read his paper, and gave some demonstrations to the Royal Society, in December 1873. He became more actively involved when Crookes submitted the work for publication in the *Philosophical Transactions*, in March 1874. Stokes appears to have made few suggestions over and above those provided by the referees[66] But he and Crookes did get into a metaphysical discussion over the title for the paper. Crookes wanted to call it "On attraction and repulsion accompanying radiation" but in the end he allowed Stokes' preferred "resulting from" instead of "accompanying". In this paper, as occasionally elsewhere, Crookes acknowledged his assistant in print:

> It is only fair to acknowledge here the assistance which I have received during the progress of these experiments from my young friend and pupil, Mr Charles H. Gimingham. Without his

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60 Fournier D'Albe, op. cit. (5), 269.
61 SML, Letters, March 1873, Birmingham.
62 SML, Letters, 29 August, St. Helier, Jersey.
63 CUL, Stokes Correspondence, C1075. Crookes had read the paper to the Royal Society, 18 June 1872, and it was published in *Philosophical Transactions* (1873), **63**, 277
64 CUL, Stokes Correspondence, C1076, 23 September 1873, and C1077, 25 September 1873.
65 CUL, Stokes Correspondence, C1078, 15 November 1873, and C1079, 21 November 1873.
66 The referees were J. Clerk Maxwell and William Thomson and their letters to Stokes about Crookes' paper are in the Royal Society archives. See DeKosky, op. cit (45), 6.

skill with the blow-pipe and delicacy of manipulation with complicated apparatus, it would have been very difficult for me to have carried out this investigation during the limited time I am able to devote to original research.[67]

This was the literal truth, but the footnote was Gimingham's only formal recognition.

The first of a series, when it appeared later in 1874, the paper created much interest and Crookes was drawn into a theoretical debate which, to a degree, dictated future experiments. In July 1874, Crookes asked Stokes for a Royal Society grant of £100 so as to continue with these. He also wanted a second paper of his to get quickly into print because he thought some experiments he had already done refuted one of the early theorists.[68]

In late August 1874, Crookes wrote to Gimingham, who was on holiday, "The lab is 'swept and garnished' and looks so tidy that I can't imagine work ever being done there. I will, however, trust you to make it decently untidy on your return . . . I can think of no 'holiday work' for you except eat as many cocoanuts as you can and keep the shells. Don't smoke too many cigarettes and come back as well as you can."[69] This kind of friendly exchange is typical. Crookes appeared to have treated his young assistant as one of the family.

In June 1874, Herbert McCleod had made public his new gauge for estimating very low pressures.[70] This was used and adapted by Gimingham as he continued work on torsion experiments in vacuum. He experimented with light horizontal beams, suspended from threads and with various discs attached to their ends. The routine appears to have been the trying of different beams, different threads, different discs, different degrees of evacuation, different heat sources etc. He even tried experiments above atmospheric pressure. Crookes, as already noted, believed in trying as many permutations and combinations as possible.[71] The work was very intricate, though much at this time was the repetition and improvement of earlier experiments. In the presence of heat the discs began to oscillate and then to revolve around the thread until forced by torsion to change direction. Crookes and Gimingham devised an apparatus for measuring the motion, again not entirely from scratch, but when combined with the new pressure gauge, it gave new information. They experimented with light (different parts of the solar spectrum) as well as heat, and with coating the discs with different substances. Light caused repulsion at very low

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67 Crookes, "On attraction", op. cit. (53), 539n.

68 See CUL, Stokes Correspondence, C1083, 11 May 1874, and C1084, 7 July 1874. It is not absolutely clear whether he received the grant, but later correspondence implies that he did. The theorist in question was Osborne Reynolds who, after watching Crookes' demonstration and doing some experiments of his own, had come to the conclusion that kinetic theory could be used to explain the heat effect. Debate at the time was over the role, if any, of residual gas on the heat/motion phenomenon. As indicated above, Crookes used experiments he had performed earlier to counter some of Reynold's claims.

69 SML, Letters, 29 August 1874, London.

70 H. McCleod, "Apparatus for measurement of low pressures of gas", *Proceedings of the Physical Society* (1874-75), **1**, 30-4.

71 Some examples: for beams he tried glass, mica, straw and brass; for suspension, spider web, cocoon thread; and for terminals, pith, cork, ivory and metals. For terminals they came to use ones with a large surface and minimum weight; earlier Gimingham had cut discs from butterfly wings, pressed rose leaves, thin split mica and other materials. See Crookes, "On repulsion", op. cit. (53). Joseph Hooker sent pith specimens from papyrus plants at Kew (SML, Laboratory Notebook IV, 3 March 1876).

pressures. It appears that it was to keep the revolutions going that the pair decided to pivot the beam and, in so doing, invented the radiometer. The instrument was first demonstrated by Crookes at the Royal Society on 7 April 1875, and was described later that month in a supplement to a paper abstract he had sent on 20 March.[72]

By using the pivot they went from two arms to four (which was more stable and was the form of the radiometer first widely demonstrated), to six or even more. The most effective early model had pith discs painted black on one side, Crookes and Gimingham having earlier noted the greater repulsion by light of black surfaces at low pressures.[73] The instrument caused much interest and Crookes' response was to retreat, publicly at least, from the theoretical front. However, in typical fashion, he asked Gimingham to try a multitude of radiometer variations and was keen to test the various theories as they came forward. On 2 June 1875 he wrote from Leeds, "I am glad you have a six-armed radiometer to work. Is it quicker than a four-armed one ?" Later that month he wrote to thank Gimingham for a diagram of the apparatus, which he said he would use for his next Royal Society paper.[74]

The laboratory notebook for July 1875 contains lengthy notes taken from a paper by Mark Watt (*Edinburgh New Philosophical Journal* (1828), **5**, 122-8) on "attraction and repulsion of lunar rays". Crookes was evidently interested in whether one could distinguish light from heat and whether lunar rays might be free of calorific properties.[75] Gimingham had earlier carried out some experiments that showed that the effect of heat on different surfaces was not significant but that the effect of light, whether from the sun or from candles, was.[76] It was shortly after this that Crookes began to get more serious theoretical help from Stokes – not that this stopped him from speculating on his own. Stokes also began sending Crookes suggestions for experiments.

It seems fair to say that Stokes became seriously involved only after Crookes' work caught the imagination of other theorists. It looked as though the radiometer might provide some new insights into the nature of light and radiation, and was thus something well worth being associated with. Stokes then adopted an almost paternal role towards Crookes (Stokes was thirteen years older), which was to the mutual advantage of both men. Stokes received early knowledge of what the best radiometer experimentalists were up to, and he could even guide some of their experiments to test theories he was interested in. Crookes, on the other hand, found an establishment ally, one who could ensure speedy publication of his work. He also had a guide to the difficult area of kinetic theory and fluid dynamics about which he knew very little. This help became more important after Arthur Schuster's experiment, announced to the Royal Society in early 1876, and confirmed shortly after by Gimingham and Crookes, which showed that residual gas in the vacuum tube was responsible for at least some of the observations[77] At this point the

72 Supplement received 20 April 1875, *Proceedings of the Royal Society* (1875), **23**, 377.

73 Light mills were being made and studied also in Germany at this time. See S. G. Brush and C. W. Everitt, "Maxwell, Osborne Reynolds and the radiometer", *Historical Studies in the Physical Sciences* (1969), **1**, 107.

74 SML, Letters, 2 June and 11 June 1875, Leeds.

75 SML, Laboratory Notebook IV, July 1875 – December 1877.

76 SML, Letters, 15 June 1875, Leeds. These results would not be accepted today.

77 A. Schuster, *Proceedings of the Royal Society* (1876), **24**, 391-2 (*Philosophical Transactions* (1876), **166**, 715-24). This experiment was conceived in 1873-74 and finally performed with the help of

theoretical discussions were taken out of Crookes' hands. In a sense, he lost control of the radiometer agenda and this loss provided the opportunity for some professional sniping, as, for example, by Crookes' old nemesis, W. B. Carpenter. Carpenter was rather quick to tell the world of Crookes' naïve theorizing, which he did in a new publication intended for a wide audience. In a spirited reply Crookes wrote, "we do not censure the dawn for not being full of daylight".[78] But with Stokes continuing to take an active interest, Crookes had little to worry about in all of this. Further, Crookes moved on to a new field of vacuum study. I think this is psychologically understandable. As an outsider to the Cambridge and Royal Society mathematical physics community, he was reluctant to join in their discussions. But he was keen to show off his superior experimental ability by introducing yet further novelties for the theoreticians to puzzle over.

The confirmatory experiments mentioned above were related to some that Stokes had already set in motion to re-test Maxwell's 1866 theory that the viscosity of a gas is independent of pressure.[79] Crookes received much editorial advice in the publication of his own results and wrote to Stokes, "I have no hesitation in accepting your alterations, they are always improvements, I would willingly avoid controversy for it wastes a great deal of time and seldom does much good, but sometimes it is forced upon me." In the same letter he tells of the viscosity experiments and includes some diagrams of the apparatus he proposes to use.[80] Four days later he wrote with more details and with some results. Yet it appears that while he and Gimingham were carrying out the viscosity experiments for Stokes, Crookes was, for his own ends, still seeking a perfect vacuum. "I asked Dr. Geissler some time ago if he would make me a radi[ometer] as he calls 'perfectly' and having platinum wires sealed in, to show that an induction coil spark would not pass. He has recently sent me the instrument." Since there was no spark across one millimeter of space "Dr Geissler has got some secret of making these non-conducting which I have not."[81] Clearly, the McCleod gauge was not yet fully trusted for low pressure measurement.

From the laboratory notebooks of 1876 it appears that Gimingham was busy for much of that year with the new viscosity apparatus. This work continued to occupy a fair bit of his time in the following years. In 1881 the results were published in two papers by Crookes. Stokes added a note on the mathematical analysis used in dealing with the large number of observational measurements.[82] The title of Stokes' note (see note 80) describes just one of the many

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Reynolds. See Brush and Everitt, op. cit. (71), 111. Crookes' confirmatory experiments were discussed with Stokes before publication. See Larmor, op. cit. (34), ii, 368-9.

78 W. B. Carpenter, "The radiometer and its lessons", *Nineteenth Century* (1877), No.1, 242-56. W. Crookes, "Another lesson from the radiometer", *Nineteenth Century* (1877), 879-88. Carpenter had been a vocal critic of Crookes' psychic researches.

79 See DeKosky, op. cit. (45), 11-12 for a discussion of this and of experiments earlier performed by Maxwell and by Kundt and Warburg. Stokes did not know of Kundt and Warburg's work until the end of 1876 and so some of the suggestions he gave Crookes that year were inappropriate. See, for example, Larmor, op. cit. (34), ii, 393: Stokes to Crookes, 23 January 1877. Maxwell's theory did not apply at very low pressures, but Crookes and Gimingham were far from having a very good vacuum.

80 CUL, Stokes Correspondence, C1088, 15 April 1876.

81 CUL, Stokes Correspondence, C1091, 19 April 1876.

82 W. Crookes, "On heat conduction in highly rarified air", *Proceedings of the Royal Society* (1881), **31**, 239- 43, and "On the viscosity of gases at high exhaustion", *Philosophical Transactions* (1881), **172**, 387-434; in the same issue see Stokes, "Note on the reduction of Mr Crookes' experiments on the