

## Primatological studies by medicine Nobel laureates

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*Primate studies of the past 140 years can be tentatively categorized into three distinct periods – classical (1876–1930), ascendant (1931–1981) and restrictive (since 1982). We define a primatologist as one who has published research conducted on nonhuman primates in peer-reviewed science journals. From this definition, among the total of 207 Nobel laureates of medicine (from 1901 to 2014), we identified 14 as primatologists. We also identified seven more Nobel laureates of medicine who had occasionally reported research on nonhuman primates. If Charles Sherrington was the most influential medical primatologist in the first half of the 20th century, then Carleton Gajdusek was the most prolific medical primatologist in the second half of the 20th century.*

At the end of year 2014, a total of 207 elite scientists of the 20th and 21st centuries had been anointed with the Nobel Prize in Medicine or Physiology, for their contributions in various disciplines of biomedical sciences<sup>1,2</sup>. In a previous survey<sup>2</sup>, these disciplines have been broadly categorized into eight areas: physiology, nutrition and enzymology; microbiology and cell biology; experimental biology, medicine and endocrinology; molecular biology and genetics; immunology; neurosciences and behaviour; clinical medicine and pharmacology. The present authors have pointed out in a survey of Darwin's major books on evolution (published between 1859 and 1872), that he was able to annotate only about 50 species of nonhuman primates<sup>3</sup>. Explosion of new discoveries of nonhuman primate species from South America, Africa and tropical Asia occurred in tandem with the wandering lust of 19th century naturalists prompted by European colonialism that reached its peak a century ago<sup>4</sup>.

Though primatology developed into a distinct discipline only five decades ago with the establishment of five major journals, i.e. *Primates* (1957), *Folia Primatologica* (1963), *Journal of Medical Primatology* (1972), *International Journal of Primatology* (1980) and *American Journal of Primatology* (1981), research of biomedical scientists on nonhuman primates did appear in a diverse range of medical and biology journals published in Europe since 1876. Theodore Ruch's 1941 compilation *Bibliographia Primatologica* is a valuable compilation in this regard<sup>5</sup>.

Previously, an attempt on reviewing the contributions of neuroscientists among Nobel laureates in medicine was made by Jasper and Sourkes<sup>1</sup>. The objec-

tive of this note is to sum up the primatological studies of 21 Nobelists in medicine.

### Method

We define a primatologist as one who has published research conducted on nonhuman primates, in peer-reviewed science journals. For the literature review, we primarily relied on PrimateLit database (<http://primatelit.library.wisc.edu/>) which covers the nonhuman primate literature from 1940 to 2010, and its precursor by Ruch<sup>5</sup> for the literature from 1890 to 1939. For information about the Nobel laureates in Medicine or Physiology, the website of Nobel Foundation ([www.nobelprize.org/](http://www.nobelprize.org/)) was relied upon.

### Results

Table 1 lists the number of Nobel laureates in medicine from 1901 to 2014. Among the 207 laureates, we identified 14 as primatologists (Table 2). The number of publications by each of these laureates in nonhuman primatology as well as their main focus of research were the primary indicators for this select list. Among these 14 scientists, if Charles Sherrington was the most influential in the first half of the 20th century<sup>6</sup>, the most prolific was Carleton Gajdusek (Figure 1). With more than 100 publications on nonhuman primates among his cumulative output of over 1000 research publications, Gajdusek had earned the distinction as the most prolific primatologist in the second half of the 20th century<sup>7–9</sup>. In chronological sequence, Charles Sherrington, Andrew Schally, Roger Sperry, David Hubel and Torsten

Wiesel, had also published more than 20 primate studies during their careers. It should be noted that Hubel and Wiesel worked as an enduring research team. In Table 3, we identify seven more Nobel laureates who had occasionally reported research on nonhuman primates. Pathology, virology and neurophysiology were the major focus of interest among the 21 Nobel laureates (Tables 2 and 3). However, the contributions of a few Nobel laureates such as Landsteiner, Sherrington and Gajdusek were interdisciplinary (Table 2). While a couple of laureates such as Vane and Elion had publications in pharmacology (Table 3), Schally, Thomas and Edwards were exceptional to have publications in endocrinology, transplantation medicine and embryology respectively.

The research contribution of each of the Nobel laureates, listed in Tables 2 and 3, for which they received recognition, is given in Box 1 in the chronological order of the award.

**Table 1.** Number of medicine Nobel laureates from 1901 to 2014

Decade	Number of medicine Nobel laureates
1901–10	12
1911–20	6
1921–30	11
1931–40	13
1941–50	17
1951–60	19
1961–70	26
1971–80	25
1981–90	22
1991–2000	21
2001–10	24
2011–14 (incomplete decade)	11
<b>Total</b>	<b>207</b>



**Figure 1.** Carleton Gajdusek, the most prolific medical primatologist (photographed by S.S.K. at the University of Illinois, Urbana-Champaign, USA in December 1982).

Specific publications on nonhuman primates of each of the laureates are also identified. For those Nobel Prize winners who have more than five publications, only five representative papers are included.

There is no reason to doubt that the nonhuman primate studies by all the Nobel laureates in medicine were meritorious for their insights and novel discoveries. However, we hesitate to record that many of their research publications until 1980 (when primatology evolved into a distinct discipline with specialized journals) lack clarity on the vital identifying status of the monkeys used for experiments, such as sex, age and nutrition information during the experiment. For illustration, we provide the following description from the classic 1949 paper of Enders *et al.*<sup>10</sup>, which reported for the first time the transmission of Lansing polio virus in monkeys from human embryo tissues: ‘Following intracerebral inoculation, the fluids from the third set of subcultures produced flaccid paralysis within 7 and 10 days respectively, in two rhesus monkeys. Microscopic examination of the spinal cords of these animals revealed lesions characteristic of poliomyelitis.’ At least the monkeys used in this experiment were identified as belonging to rhesus macaque. But other vital indicators such as sex and age are excluded. Though the obtained results from such experimental nonhuman primates were sound within the context set by the experimental protocols, in the absence of such details, it becomes tedious when other researchers make attempts to

**Table 2.** Primatologists among medicine Nobel laureates

Medicine Nobel laureates	Year of Nobel award	Field(s)
Karl Landsteiner (1868–1943)	1930	Hematology, immunology, virology
Charles Sherrington (1857–1952)	1932	Anatomy, neurophysiology
Edgar Adrian (1889–1977)	1932	Neurophysiology
John Enders (1897–1985)	1954	Virology, pathology
Thomas Weller (1915–2008)	1954	Virology, pathology
Frederick Robbins (1916–2003)	1954	Virology, pathology
Carleton Gajdusek (1923–2008)	1976	Virology, pathology
Andrew Schally (b. 1926)	1977	Endocrinology
Roger Sperry (1913–1994)	1981	Neurophysiology
David Hubel (1926–2013)	1981	Neurophysiology
Torsten Wiesel (b. 1924)	1981	Neurophysiology
Donnall Thomas (1920–2012)	1990	Transplantation medicine
Francoise Barre-Sinoussi (b.1947)	2008	Virology, pathology
Luc Montagnier (b. 1932)	2008	Virology, pathology

**Table 3.** Medicine Nobel laureates with occasional publications on nonhuman primates

Medicine Nobel laureates	Year of Nobel award	Field(s)
Charles Nicolle (1866–1936)	1928	Pathology
Baruch Blumberg (1925–2011)	1976	Virology, pathology
Roger Guillemin (b.1924)	1977	Endocrinology
John Vane (1927–2004)	1982	Endocrinology
Gertrude Elion (1918–1999)	1988	Pharmacology
Stanley Prusiner (b. 1942)	1997	Pathology
Robert Edwards (1925–2013)	2010	Embryology

confirm the reported findings, even when identical species are used.

Even in 1993, we could locate a long-term study on ‘prion dementia’ published in *Lancet*, of which Gajdusek is the senior author<sup>11</sup>, where the specific details of the primates used remain hidden in the laboratory note books and are not presented in the paper. The only description provided under the ‘Materials and Methods’ section for this study states, ‘85 primates (chimpanzees, New World monkeys, and Old World monkeys) were inoculated intracerebrally with 0.05–0.1 ml of a 1–10% saline suspension of freshly thawed frozen cortical brain tissue from the 46 cases. Inoculated animals were kept under surveillance for up to 20 years, and any animal that died was examined histopathologically for evidence of spongiform encephalopathy.’ Other than chimpanzees, readers are left to guess which primate species belonging to New World monkeys and Old World monkeys were tested by these researchers.

**Discussion**

For convenience, we divide primatology studies into three distinct periods –

classical (1876–1930), ascendant (1931–1981) and restrictive (since 1982). The cut-off dates are chosen for convenience. The commencement of classical period is set by us as 1876 for three main reasons. First, Charles Darwin published his short paper ‘Sexual selection in relation to monkeys’ in *Nature* in that year. Secondly, David Ferrier (1843–1928), the Scottish neurologist, published his classic *The Functions of the Brain* in 1876, which focused monkey as an experimental animal model for the first time<sup>12</sup>. Thirdly, in the same year, Leopold II, the King of Belgium, summoned a conference at Brussels that resulted in the creation of an International Association for the Exploration and Civilization of Africa<sup>4</sup>. This resulted in the European colonization of the African continent, which in turn influenced expanded identification and quantitation of numerous nonhuman primates by European naturalists. Karl Landsteiner received his Nobel Prize in medicine in the year 1930. This period from 1876 to 1930 was the exploratory phase in primatology, stimulated by curiosity among human’s nearest evolutionary relatives.

The ascendant period (spanning from 1931 to 1981) saw the proliferation of

**Box 1.**

Charles Nicolle: work on typhus<sup>19,20</sup>.  
 Karl Landsteiner: discovery of human blood groups<sup>21–25</sup>.  
 Charles Sherrington: discovery regarding the function of neurons<sup>16, 17, 26–28</sup>.  
 Edgar Adrian: discovery regarding the function of neurons<sup>29,30</sup>.  
 John Enders: discovery of the ability of poliomyelitis viruses to grow in cultures of various types of tissue<sup>10, 31–35</sup>.  
 Thomas Weller: discovery of the ability of poliomyelitis viruses to grow in cultures of various types of tissue<sup>10,34,35</sup>.  
 Frederic Robbins: discovery of the ability of poliomyelitis viruses to grow in cultures of various types of tissue<sup>10,34,35</sup>.  
 Baruch Blumberg: discovery concerning new mechanisms for the origin and dissemination of infectious diseases<sup>36–40</sup>.  
 Carleton Gajdusek: discovery concerning new mechanisms for the origin and dissemination of infectious diseases<sup>41–45</sup>.  
 Roger Guillemin: studies on pituitary gland peptides<sup>46,47</sup>.  
 Andrew Schally: discovery concerning new mechanism for the origin and dissemination of infectious diseases<sup>48–52</sup>.  
 Roger Sperry: discovery concerning the functional specialization of the cerebral hemispheres<sup>53–57</sup>.  
 David Hubel: discovery concerning information processing in the visual system<sup>58–62</sup>.  
 Torsten Wiesel: discovery concerning information processing in the visual system<sup>58–62</sup>.  
 John Vane: discovery concerning prostaglandins and related biologically active substances<sup>63,64</sup>.  
 Gertrude Elion: discovery of important principles for drug treatment<sup>65,66</sup>.  
 Donnall Thomas: discovery concerning organ and cell transplantation in the treatment of human disease<sup>67–71</sup>.  
 Stanley Prusiner: discovery of prions – a new biological principle of infection<sup>72,73</sup>.  
 Francoise Barre-Sinoussi: discovery of human immunodeficiency virus<sup>74–78</sup>.  
 Luc Montagnier: discovery of human immunodeficiency virus<sup>79–83</sup>.  
 Robert Edwards: development of *in vitro* fertilization<sup>84–86</sup>.

nonhuman primate studies followed by the trend set by the classical period primatologists. Increased research funding by government agencies, public health demand to cure diseases such as polio by vaccines in late 1940s, establishment of six regional primate research centers in USA in 1960s, and Sputnik-era rivalry between the superpowers (USA and USSR) for space exploration in which nonhuman primates were used as models for human space travel in late 1950s and whole of 1960s influenced this period<sup>13,14</sup>. This period came to an end with 1981 Nobel Prizes for Sperry, Hubel and Wiesel. Sperry's pioneering invasive studies on split brain monkeys was recognized for his discovery concerning the functional specialization of the cerebral hemispheres. Hubel and Wiesel were jointly honoured for their discoveries concerning information processing in the visual system of monkeys. Experimental

reports of Hubel and Wiesel on monkeys were also invasive in nature.

The restrictive period emerged in the 1980s due to factors such as awareness of the invasive research protocols then practised by primatologists, the rise of animal rights activism in Europe and USA, xeno-transplantation trials of non-human primates to humans (such as baboon heart or baboon liver to baby or sick patient), as well as positive thoughts on preservation of endangered primate species, in association with the depletion of tropical rainforests. Activism of animal rights movements such as Animal Liberation Front in the UK (established in 1976) and People for the Ethical Treatment of Animals in USA (established in 1980) made deep impact on nonhuman primate research in 1980s by influencing the funding agencies as well as voluntary donations from private individuals. Only a handful of scientists,

such as Hubel<sup>15</sup>, had the courage to oppose the actions of animal rights activists openly. As such, it is a misfortune that quantity as well as quality of studies on monkeys and apes remains depleted in the 21st century.

Overall, we wish to add that research publications in primatology cannot be evaluated by sheer quantity of productivity alone. Papers of the classical period (especially that of Sherrington) were lengthy, descriptive and spanning 100 pages<sup>16,17</sup>. Many were single-authored or had two authors. Papers of the restrictive period were less descriptive and limited to a couple of pages, with the number of authors exceeding 10. A good example is the one that appeared in *Lancet* in 1984, describing a successful transmission of lymphadenopathy-associated virus in two chimpanzees, in which Barre-Sinoussi and Montagnier were among 16 co-authors<sup>18</sup>.

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