

## Spirited evolutionist Robert Broom and Stellenbosch revisited on a zoological centenary\*

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The Department of Zoology at the University of Stellenbosch, of which I'm proud to be an honorary member, has had a long and illustrious history. Here I celebrate the memory of its foundation professor, a man 'sacredly devoted to the pursuit of science'.



Robert Broom (1866–1951), the spirited evolutionist. (Courtesy Transvaal Museum.)

### Zoology in 1903

What was the state of biology in 1903? Genetics, as a science, was just beginning. Gregor Mendel's laws of heredity had only two years earlier been re-discovered by Hugo De Vries in the Netherlands, K.E. Correns in Germany and Erich Tschermak von Seysenegg in Austria. Only 35 years earlier, Mendel, in the Augustinian monastery at Brno in what is now the Czech Republic, had proposed these laws from his studies on pea plants. By 1905, it was found that Mendel's laws applied to human beings: the family concerned showed brachydactyly inherited as a simple Mendelian dominant trait. Each of the second to fifth fingers had only two phalanges, instead of three as is the fashion!

By 1903, no ancient hominid fossils had been brought to light in any part of Africa. It was widely held that the cradle of humankind was in Asia. Java Man had been discovered in 1890/91 in Indonesia (then known as the Dutch East Indies), whilst in China, in 1903, K.A. Haberer found in a Peking pharmacy a human tooth which was recognized as that of a fossil man: thus began the unfolding of the tale of Peking Man. So informed people 100 years ago were looking to the Far East as the original home of humankind.

Experimental embryology was a product of the late 19th century. Wilhelm Roux's seminal works on *Entwicklungsmechanik* appeared in 1888 and 1895. Ecology, too, would have been a part of the thinking of biologists, for it had been formally defined as a scientific discipline by Ernst Haeckel as early as 1866 (the year in which Robert Broom was born). Histology, cytol-

ogy, a tincture of cytochemistry and even a smudge of cytogenetics were established branches of study, although such refinements as phase contrast microscopy, electron microscopy, ultraviolet absorption spectrophotometry, radiation biology, and X-ray diffraction studies were not known. The discovery of Röntgen rays (or X-rays) had happened only eight years earlier, but their application in biological research had hardly begun.

That, in sum, was the state of play when Robert Broom was appointed as the foundation professor of zoology at the University of Stellenbosch. By an interesting synchronicity, also in 1903, Arthur Dendy was appointed as the first professor of zoology at the South African College, forerunner of the University of Cape Town.<sup>2</sup> As far as I have been able to trace, Dendy at Cape Town and Broom at Stellenbosch<sup>3</sup> were the first two professors of zoology in southern Africa. What of Johannesburg? The South African School of Mines and Technology, the precursor of the University of the Witwatersrand, did not set up a department of zoology until 1917 when H.B. Fantham was appointed head, serving from 1917 to 1932.<sup>4</sup>

### Robert Broom and Stellenbosch

Such was the zoological background to Robert Broom's tenure as professor of zoology and geology at Victoria College from August 1903 to 1909. By today's standards, such a combination would be decidedly odd. However, according to his biographer, George Findlay,<sup>5</sup> it had been the practice at Broom's alma mater, Glasgow University, until 1902 to combine zoology and geology in one chair.

When Victoria College offered him the chair, Broom had obtained his M.D. degree and had some 65 publications to his name. He was 37 years of age. While he was at this university, his studies on

Karoo fossil reptiles led to a D.Sc. thesis, the degree being awarded by the University of Glasgow in 1905.

Broom seems to have been quite the most extraordinary of the early professors at the university. He defied the senate's wishes that he take a roll call at each lecture and enter the names of defaulters in an Absentee Book. He pointed out that his lectures were extremely well-attended and his students passed their examinations. He agreed to reconsider the matter only if any other senate member had a better record. Apparently no-one did.

Of his lectures, Findlay states, 'He was thoroughly versed in the subject matter of his lectures and scarcely bothered much with preparing them. They had a spontaneous character which was made even more lively when Broom strayed from the subject to express his views on topics of wider concern such as religion and politics'. While at Victoria College, Broom's students included such men as C.G. ('Oom Coert') Grobelaar, who became a pioneer in the study of the Khoisan peoples and human growth<sup>6</sup>; D.E. Malan, the zoologist; the surgeon, Tielman Roos Scholtz and Gilles de Kock, the veterinary scientist. His favourite pupils from Stellenbosch are reported to have been Christo Beyers, the surgeon, and P.J. Du Toit, an exceptional South African veterinary scientist and one of a rather small number of South African scholars to have been made a Fellow of the Royal Society of London. Apart from those busy years at Stellenbosch, Broom was not blessed with many research students, because he became a rural medical practitioner and much later a member of the Transvaal Museum.

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In later years, his principal protégé was John Talbot Robinson, who had a distinguished, albeit rather brief, career as a palaeo-anthropologist and as Broom's successor at the Transvaal Museum.<sup>7</sup>

### Robert Broom's career

For those who would seek to know more about the life of Robert Broom, one of the most remarkable scientists to have made South Africa his home, I can warmly recommend the biography by Findlay, published in 1972.<sup>5</sup> Here let me give a brief summary of his life. It is eminently worthwhile to ponder over the lives of great men and to dissect what messages one can receive from them. It has been my experience that palaeo-anthropologists are commonly every bit as interesting as the fossils they recover. Indeed, in 1951, J.B.S. Haldane stated that 'Broom is almost as worthy of study as the fossils he has collected. He did the work of a dozen ordinary lifetimes in his spare time. It is good to think that such a man has made the most important discoveries of our generation concerning human evolution.' (cited by Findlay<sup>5</sup> in the Introduction to his biography of Broom).

The palaeontologist, D.M.S. Watson, according to Findlay,<sup>5</sup> declared that he never knew a man more 'sacredly devoted to the pursuit of science' than Broom. Broom 'wanted to know' so keenly that his opinion was never to be tossed lightly aside by any less dedicated scientific competitor. With this fiery outlook Broom pioneered mammalian and human origins in the fossil record with the most naïve equipment imaginable. Everything was done with eyes, hands, brain, good health and a few simple tools.' Watson was sure that Broom 'showed himself possessed of genius.'

Broom was born in Paisley, Scotland, in 1866. At the University of Glasgow, he graduated in science in 1887 and medicine in 1889. He spent the years 1892 to 1896 in Australia, where his patients had to compete for his time with marsupials, monotremes and their embryos, and with fossils in the Wombeyan Caves of New South Wales. Even before he went to Australia, he had published seven articles on comparative anatomy, obstetrics (in which he obtained the William Hunter Medal at Glasgow), and teratology. The years in Australia were fruitful, yielding another twenty publications — and a wife, Mary Baird Baillie of Scotland. She remained at his side from 1893 until his death in 1951.

Among his other attainments whilst in Australia, he obtained an M.D. degree of

the University of Glasgow: his thesis was devoted to the comparative anatomy of the organ of Jacobson, that enigmatic little structure on each side of the nasal septum.<sup>8</sup> Just imagine doing that in a small town, Taralga, in the Blue Mountains of New South Wales, far from library resources, having to do all his own drawings freehand in an era long before photocopying or the computer had arrived. His father, John Broom, in Edinburgh laboriously copied scientific articles and even drawings, sending them by sea to Australia.

Leaving Australia in May 1896, the Brooms spent a year in the British Isles. This enabled him to visit the Natural History Museum and make acquaintance with some Karoo fossils. He realized that great opportunities might await him in South Africa, which seems to have determined him to move to South Africa in 1897. Here he remained until his death in 1951. He initially worked as a rural medical practitioner in Port Nolloth, Garies, Port Elizabeth and Pearston. He seemed to prefer life in isolated country districts where living vertebrates and fossils were always to be had.

His recognition of the probable ancestors of the mammals led to his Croonian Lecture to the Royal Society of London in 1913, devoted to the origin of mammals.<sup>9</sup> Later, there followed two weighty volumes on *The Origin of the Human Skeleton*<sup>10</sup> and *The Mammal-like Reptiles of South African and the Origin of Mammals*.<sup>11</sup> His major palaeontological contributions earned him a Fellowship of the Royal Society (London) in 1920 and its Royal Medal in 1928.

After leaving the University of Stellenbosch in 1909, he carried on as a medical practitioner, took postgraduate courses in surgery in the United Kingdom and in 1916 settled in the village of Douglas, west of Kimberley. It was there that Broom first learned of the Taung skull, which the anatomist Raymond A. Dart (1893–1988) revealed to the scientific world in 1925.<sup>12</sup> Within weeks of the announcement, Broom hurried to Johannesburg and spent a weekend studying the child's skull. When he entered Dart's office at the Wits Medical School Anatomy Department, he darted over to the desk on which the skull was lying, knelt down to examine the specimen for a few moments, then looked up to the professor of anatomy, with a beatific expression on his face, and declared, 'Dart, I bend the knee before our common ancestor!'. Broom (like Dart) was convinced that the Taung fossil was allied to the human, and not to the chimpanzee or gorilla as many claimed at the time. He

immediately wrote a couple of papers in support of Dart's claims. In his 1933 book, *The Coming of Man: Was it Accident or Design?*,<sup>13</sup> he went beyond what Dart had done and confidently assigned the genus *Australopithecus* to the family Hominidae. Broom also offered a projected reconstruction of how the adult might have looked; in remarkable detail it prognosticated the form of the adult australopithecine specimens subsequently found at Sterkfontein.

As Broom was already sixty-seven years old and living in penury, Dart wrote to General J.C. Smuts and J.H. Hofmeyr and informed them how wasteful it was that a scientist of Broom's worldwide repute should be languishing in the backwoods. He was unable even to finance the journey to take up his presidency of the South African Association for the Advancement of Science. In 1934, a year later, Broom was offered a temporary post at the Transvaal Museum, Pretoria, where he remained for 17 years. He immediately set about searching for an adult *Australopithecus*. This search carried him to the Skurweberg and to Gladysvale.

In August 1936, one of Dart's medical B.Sc. students, Harding Le Riche, and a neuro-anatomist in Dart's department, G.W.H. Schepers, brought Broom some fossil baboon and monkey skulls and endocranial casts, which they had recovered from a dolomitic cave deposit known as Sterkfontein. Broom rushed out to Sterkfontein with Schepers and Le Riche. Within nine days he had the first adult specimen of the same kind of creature as Dart had called *Australopithecus africanus*.<sup>5</sup> It was the start of a series of discoveries of australopithecine remains at Sterkfontein. That one site, at the hands of Broom, later helped by John T. Robinson, and of myself, assisted by Alun R. Hughes and then by Ronald J. Clarke, has yielded over 700 fossil hominid specimens, including no fewer than four partial hominid skeletons. These unique features played the primary role in persuading the World Heritage Centre of UNESCO to place Sterkfontein and eleven neighbouring fossil sites on the World Heritage List on 2 December 1999.

The Sterkfontein fossils were initially named by Broom *Australopithecus transvaalensis* — a different species within the genus to which Dart had assigned the Taung child. Broom was a great 'splitter'! When some seemingly diagnostic teeth came to light at Sterkfontein, Broom<sup>14</sup> considered them to be so different as to justify his erecting a new genus, *Plesianthropus* (the shortened form of which

furnished the colloquialism Mrs Ples). Still later, Broom's assistant, John T. Robinson (1923–2001), lumped the Sterkfontein species back into *Australopithecus africanus*, but as a representative of a distinct subspecies, *A. africanus transvaalensis*.<sup>15</sup>

In 1938, Broom recovered fossil remains of a different kind of ape-man, with larger cheek-teeth, smaller anterior teeth and a flatter face<sup>14</sup> at Kromdraai in the Bloubaank River Valley. He considered this also to be a hominid, but he erected a new genus and species to classify it, *Paranthropus robustus*. Ten years later, another site across the Bloubaank River Valley, Swartkrans, yielded more specimens of this robust ape-man to Broom and Robinson. Broom<sup>16</sup> erected a new species of the same genus — *Paranthropus crassidens* — as its cheek-teeth appeared to be still larger than those of the Kromdraai hominid. The idea of generic distinctness for these forms did not gain much support, and most investigators of the period accommodated them in the species *Australopithecus robustus*. I later<sup>17,18</sup> proposed retaining the name but at subgeneric status as *Australopithecus (Paranthropus) robustus*. The important contribution that flowed from Broom's discoveries was the demonstration that not all of the early hominids were ancestors of the later ones, suggesting that the early hominids must have diversified and branched into different lineages. That realization proved a difficult pill to swallow. For decades afterward there were scholars who tried to place all of the hominid fossils on a single lineage leading to modern humans. For most, however, Broom's revelations at Kromdraai and at Swartkrans provided unequivocal evidence for a prior splitting into at least two lineages.

Not long before Broom died in 1951, Robinson made an historical find at Swartkrans. He showed that, along with the robust ape-man, the cave held remains of a more advanced form to which Broom and Robinson<sup>19</sup> gave the name *Telanthropus capensis* (later reclassified as *Homo erectus*). This was the first instance of early *Homo* contemporary with late-surviving, small-brained, ape-man remains. Later, Clarke<sup>20</sup> suggested that this Swartkrans hominid might lie somewhere between *H. habilis* and *H. erectus*.

During the course of his long career, Broom published 456 articles and books. There were three detailed monographs on the Australopithecinae, which were published by the Transvaal Museum in 1946, 1950 and (posthumously) 1952.<sup>21–23</sup> These played a crucial role in converting

some opponents of Dart and Broom to accept their claims for the ape-men. For instance, Broom's 1946 monograph was largely instrumental in leading the British anatomist and anthropologist, Sir Arthur Keith (1866–1955), to drop the vigorous opposition he had maintained ever since 1925.<sup>24</sup>

So Broom had not one but two distinguished scientific careers: his work on the Karoo mammal-like reptiles carried him to the top, as marked by his FRS and his Royal Medal of the Royal Society. At seventy years of age, he began a new career — on the study of South Africa's wonderful ape-man fossils and their bearings on human evolution. This second phase lasted from 1936 until the day on which he died, 6 April 1951. He was then 84½ years old.

### A few personal memories of Robert Broom.

I had the privilege of knowing Broom for the last six years of his life. Indeed, I believe I am the only person living who had the unique experience of working closely with all three of the scientists whom Robert Ardrey called 'The Three Wild Men of Africa' — Raymond Dart, Robert Broom and Louis Leakey of Nairobi. Before he died, Ardrey (the author of *African Genesis*) gave me permission to use his memorable phrase as the title of an envisaged book, *The Three Wild Men of Africa, Dart, Broom and Leakey: the Men Behind the Discoveries*. Whether I shall live long enough to fulfil this wish (I am now 78) I do not know.

I first fell under Broom's spell when I was nineteen years old and a member of the third year medical B.Sc. class at Wits. Each week he would come across by train to Park Station from Pretoria, where he was working in the Transvaal Museum, walking up Hospital Hill to the old Medical School. With a group of less than a dozen medical students, Broom fired us with the most enthralling lectures. He used the blackboard profusely, covering it with freehand drawings of great reptiles and near-mammals of the Karoo, and of the australopithecine ape-men which had been recovered from Taung, Sterkfontein and Kromdraai between 1924 and World War II. He delineated freehand the subtle differences between the different findings. Now and again he would fumble in his waistcoat pocket and take out two or three superbly preserved fossil hominid teeth he had just recovered from Sterkfontein, displaying these to our eager and impassioned eyes: 'That's the sort of thing you can find if you know where to look

and have the right informed eyes and fingertips. The country is crying out for your contributions!'

Then he would look at his watch and declare, 'Oh my fur and whiskers, it's half past twelve. I have to get back to Pretoria. I am nearly 79, most of my family have died at 80, and I've got a great deal of work to do before my time comes. Good morning, gentlemen'. In the event he was far too busy to die at 80, going on for almost five more years in which he published another seventy works, including three books!

So enthused were we by his lectures that, in the April vacation of 1945, we went to Sterkfontein and for a week camped out not far from the fossil site. It was so thrilling an experience that we decided to build on it.

In the July vacation we organized a multi-departmental expedition to Makapansgat in what is now the Limpopo province. The most dramatic outcome was that, at the Makapansgat Limeworks, we recovered several baboon and monkey skulls. We showed them to our mentor, Broom, and he found that there were new species and even a new genus among them. He rushed into print — I think it was the *Sunday Express* — with the story under a banner headline, 'Students make 300 000 years old discovery'. As it happens, the stratum from which the primate fossils emanated was later dated just ten times as old, 3 million years before the present. This gave us enormous encouragement, but it had other significant results.

First, as Dart (1959) describes in his autobiography, *Adventures with the Missing Link*,<sup>25</sup> these student discoveries were directly responsible for bringing him (Dart) back into a field of research which he had long previously abandoned. Secondly, there followed a series of expeditions organized by students in the Anatomy Department over the next two years, and the recovery of additional mammalian fossils. Thirdly, perhaps it was these stirring events that played a major part in drawing me into the field of palaeo-anthropology, although at that time I was working mainly on the chromosomes of rodents (the topic of my Ph.D.) and on the living peoples of Africa, whilst simultaneously carrying on my medical studies. Fourthly, two years after our first student expedition, James Kitching, whom Dart had sent to search the limeworkers' dumps, found the first cranial part of an australopithecine. 'Makupane' had become South Africa's fourth ancient hominid site.

During my 'science year', Broom invited our class over to have tea with him and Mrs Mary Broom in their little suburban home in Pretoria. His house was a collector's paradise including a few Rembrandt sketches. How could he afford such wondrous art works? Reading our minds, he told us: at the sale he was the only person present who knew that they were authentic, so he picked them up for a song! 'Always', he told us, 'make sure you know more than anyone else. That's my secret for success in art-collecting — and in science.' He had one of the greatest private collections of Transvaal stamps, including a famous philatelic error in which the old ox-wagon stamp of the Zuid-Afrikaansche Republiek was printed with two disselbome instead of one. I shall never forget the hand-written letter he sent me after he had examined the primate skulls we recovered on our first expedition. 'You and your colleagues have made a discovery as important as, or even more important than, Columbus's discovery of America.'

In April 1951, Broom was lying in bed struggling to breathe and to complete his last book. In England, Sir Solly Zuckerman (originally of Cape Town) had late in 1950 attacked Broom's work, claiming that the australopithecines were simply apes. Broom had not himself replied to Zuckerman's attack. He did so in the final section of his last monograph, on the Swartkrans ape-man.<sup>23</sup> G.H.R. Von Koenigswald, discoverer of many Javanese fossils of *Homo erectus*, told me how he had visited Broom during his last months: there was the shrunken gnome-like little man, his skin pale and cadaverous, but a fierce light smouldering in his eyes: he was writing, writing that final chapter of the monograph. When he became aware of Von Koenigswald in the doorway, he looked up and his opening remark was, 'That damned Zuckerman'.

On Friday morning, 6 April, he made the final corrections to his manuscript. His nephew Cecil Broom tells how Broom put down his pen and was heard to say, 'Now that's finished and so am I.' He died that evening.

No-one had thrown more light on the origins of the mammals and on human evolution. As Raymond Dart said of him, he made medical practice merely a means to live while he sought for facts bearing on evolution

### Broom and the spirit

I should like now to take you back to the first words of this lecture's title: 'Spirited evolutionist Robert Broom'. I have said

enough about Broom's personality to show that he was spirited in the sense of animated, lively, energetic. I turn now to the other implication of spirited: occupied or possessed by a spirit.

From his earliest days in Scotland, he was a strong believer in the existence of spiritual forces in nature. In his 1933 work he set out his belief that the Taung child was a 'missing link' and provided irresistible evidence that the hominid family had arisen from such creatures. He showed himself in that book, as in his earlier writings, to be a staunch evolutionist who accepted the evolution of humanity. Yet that important book of 1933 bore the title, *The Coming of Man: Was it Accident or Design?*

Only twelve years later, my anatomy and physical anthropology teacher, Alexander ('Sandy') Galloway told us of Broom's almost uncanny knack of knowing where to search and where to dig. Broom didn't consider it good luck, as Louis Leakey in Kenya did when his efforts were rewarded.<sup>26</sup> He was convinced that he was being guided by the spiritual forces in nature.

Broom went further. He said that the whole trend in the evolution of mankind had been towards a creature which could commune with these spiritual agencies. Lecturing to a crowded Harveian Lecture Theatre in the Wits Medical School about 55 years ago, he went on to say that very few humans had reached a stage where they could commune with these spiritual agencies — persons like Moses, Confucius, Christ, Mohamed — and then slyly and naughtily added — and Robert Broom! Broom based his ideas on spiritual agencies and the soul in his interpretation of evolution and especially of the mechanisms propounded to explain it.

He had long held that genetic mutation and natural selection were unable to account for all the facts of evolution. The essence of the neo-Darwinian synthesis was that changes occurred in the genetic material and that these mutations were then available to be operated upon by natural selection. According to Broom, this mechanism could not explain this critical problem: how new structures could arise when their presence or absence in the organism *at first* could have made no difference to survival. Broom saw in the spontaneously proffered variations of Peter Medawar, the intervention of a spiritual agency, the unconscious soul.

It's fifty years since Broom died and some of the problems that worried him are no longer quite so worrisome to evolutionists today. We now know that a

very high percentage of the species in the fossil record did not survive. Evolution was the exception; extinction was the rule! So we may infer that most of the 'spontaneously proffered variations' were not of any selective advantage.

In Broom's view, the 'unconscious soul' was responsible for the changes of structure and plan of *all* living things. But *human* beings are distinguished by having a 'conscious soul' as well. It is the development of conscious souls that Broom held was the purpose of evolution.

I want to put this question: was Broom not a very good scientist because he allowed himself to speculate publicly on such matters? This is part of a broader question, that of science and ethics, and this in turn is a component of the riddle of the nature of science and its social relations.

One of the greatest evolutionists of the twentieth century was Julian Huxley. Like Teilhard de Chardin and like Theodosius Dobzhansky, Huxley, one of the authors of the neo-Darwinian synthesis,<sup>27</sup> was concerned about the mystery of consciousness. As he put it, 'In modern scientific man, evolution was at last becoming conscious of itself.'<sup>28</sup> Huxley, like Teilhard, had a value system which related to what he considered to be the progressive trends in evolution. Throughout my career, my mind has been preoccupied with the nature of science and its social relations. Today, more and more people are looking at the interdigitated questions of Science and Ethics. There is an interesting historical aspect to this question.

Until World War II, the scientific search for the truth was considered to be a mission for the good of all, to be shared whether there was a war on or not. As Jacob Bronowski<sup>29</sup> reminded us, the roots of this attitude went back to the 1660s when the Royal Society (of London) and the Académie des Sciences (of Paris) were founded. Yet, during the 60-year Napoleonic wars, scientists in France and Britain freely exchanged information, visits, letters and awards. For example, when Edward Jenner discovered vaccination against smallpox in 1798, the news circulated freely on both sides of the Channel. As Jenner wrote, 'The sciences were never at war'.<sup>30</sup>

Between the two world wars, most scientists — if they thought of the matter at all — believed fervently in the pursuit of the truth, wherever it might lead. Science shared with religion this respect for the truth.

Even then, there were two schools of

thought. Some people were of the opinion that the spirit of science was exclusively dispassionate, objective, cold, aloof. Questions of ethics and of aesthetics, these scholars believed, resided in the realm of philosophy, not of science. For others, such a definition was a purist's distillation of the essence of science, a caricature that was too other-worldly, too absolutist, too essentialist. They pointed out that science without an ethic might produce such aberrations as racism (and a supposed scientific underpinning for its political manifestations such as Nazism, apartheid and the latest horror, 'ethnic cleansing'). For this group of scientists, it was irresponsible to exempt or exonerate science from the ethical consequences of its discoveries.

The view that scientific research should be pursued wherever it might lead went up in smoke, once and for all, on 6 August 1945, when the atomic bomb was dropped on Hiroshima. The Bomb raised in an acute form the question of the interrelationships of science, society and ethics. This was true, not only for the physical sciences, but also for the biological sciences. What of science and the aesthetic?

I have myself cried out repeatedly that human evolutionary studies are beset with far too many species names and too much taxonomic complexity to give one confidence that this picture reflects nature. *Sancta simplicitas!* When Dobzhansky<sup>31</sup> wrote a foreword to my first book on chromosomes and evolution<sup>32</sup> nearly fifty years ago, he included this sentence: 'An extreme simplicity is characteristic of most of the really important conclusions in science!'

The Parsimony Principle, which is widely applied in modern phylogenetic analyses, may be another example. The same principle underlies Occam's Razor, promulgated in the 14th century by the Franciscan, William of Occam. With delightful simplicity he formulated the maxim: 'It is vain to do with more what can be done with fewer.' These examples show that aesthetic criteria play a part in the day-to-day practice of science.

Even scientists who do not theorize about the philosophy or philosophies of science, nevertheless give expression, almost unconsciously, to this idea. C.P. Snow<sup>33</sup> wrote that any practising scientist would confirm how frequently one hears such phrases as 'A beautiful idea' or 'an elegant hypothesis' — as though beauty, elegance, prettiness, sweetness, were yardsticks with which to judge scientific novelty or excellence.

Then there are moments of aesthetic

ecstasy which come upon the scientist as he finds a critical solution, makes a crucial observation or lights upon a decisive hypothesis. Snow cites Janos Bolyai's great cry of triumph when he saw that he could construct a consistent, non-Euclidean geometry. All of these were voices of aesthetic bliss and it would be folly to exclude them from the scientific enterprise.

In the 58 years since I undertook my first research, I have had the good fortune to experience such moments of aesthetic joy accompanying scientific discoveries. I conclude that science does not exist in a social and intellectual vacuum. It has both ethical and aesthetic dimensions. These help to integrate the creative agenda of science into its societal and philosophic milieu. Our definitions of science must encompass these facets. All of us should rejoice that one can be a scientist and at the same time a human being steeped in the mores and ethos of society, and at one with other creative purposes of mankind such as the arts, history, philosophy, religion.

Let me conclude with an appeal for universality. Societies which are not European provide alternative scientific models to that of a racially — and culturally — narrow, European society. May our eyes be opened to this broader vision of science.

If this is true of science, I suggest it applies also to religion. This comment is part of a global problem: there is a desperate need for our world to resist further atomization and disintegration. Would it be asking too much to propose a mission for the Third Millennium to strive ever more energetically towards synthesis? Perhaps Robert Broom's life and philosophy showed us the way. What we need is not a neo-Darwinian synthesis, but a neo-Broomian synthesis!

I am most indebted to Professors 'Koot' Reinecke and Terry Robinson of the Department of Zoology, University of Stellenbosch, for inviting me to deliver the John Ellerman Commemorative Lecture for 2003 on the occasion of the centenary of the Zoology Department. I acknowledge with appreciation my debt, so many years ago, to Dr Robert Broom, whose memory and whose spirit are still so alive. Words cannot express appropriately how much I owe to Heather White for her help in the preparation of this manuscript and in so many other ways. Financial support was received from the PAST Fund, the Ford Foundation, the French Embassy of South Africa and the University of the Witwatersrand, Johannesburg.

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