The neurophysiologist Ruth Bleier (1923-1988), a pioneer in the feminist critique of science

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ABSTRACT

The neurophysiologist Ruth Bleier (1923-1988) became a pioneer in the feminist critique of the science of her time. Her studies on hypothalamic anatomy and physiology in different animal species led her to be considered one of the most distinguished figures in this area. She developed atlases of the hypothalamus of different animal species and made significant discoveries on the cells associated with the ependyma of the third ventricle, sexual dimorphism of some hypothalamic nuclei, and the role of sex hormones in the development of the brain. A political activist in her youth, she had serious clashes with the dominant McCarthyist doctrine of her time, and from the 1970s she dedicated her energy to the feminist struggle from her position at the University of Wisconsin-Madison. She also studied the possible sex differences in the corpus callosum and denounced the androcentric biases in the positions of official science on the concepts of sex and genre. Her early death due to cancer truncated her career at a time of great intellectual creativity.

KEYWORDS

Ruth Bleier, neuroanatomy, neurophysiology, hypothalamus, sexual dimorphism, feminist critique of science

Introduction

The year 2023 marks the centenary of the birth of the remarkable neuroanatomist and neurophysiologist Ruth Bleier (1923-1988), who deservedly became an international authority in the study of the hypothalamus of different animal species. Over two decades, she developed atlases of the hypothalamus of several species, which represented a milestone in the understanding of the form and function of this brain structure. She was also an important figure in the study of hypothalamic sexual dimorphism and of the ependymal and supraependymal cells of the third ventricle. Bleier was committed to the issues of her time and was politically and socially active during her youth, protesting particularly against the Korean War and the nuclear arms race; because of this, she was a victim of McCarthyist repression, which suffocated the American society of the time. By the 1960s, she focused her efforts on the fight for women's rights. From her privileged position in neuroscience, which was a battlefield in the study of sex and gender, she was a pioneer in denouncing the androcentric bias that governed the official science of her time. For instance, she criticised the studies on the differences between men and women in cognitive functions and structure of the corpus callosum, as well as the hasty extrapolation of behavioural findings from experimental animals to humans, ignoring the great complexity of the human brain and the influence of the environment and learning.

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Figure 1. Ruth Bleier. Source: Wisconsin Alumni Association.

Unfortunately, Ruth Bleier died due to cancer at an especially productive time in her career, which probably deprived us of many developments in the fields of neuroscience and feminist activism. This article describes her personal and scientific life, both in the field of neuroanatomy and neurophysiology and in her critique of androcentrism in science.

Material and methods

A systematic literature search was performed to gather scientific articles by Ruth Bleier and articles addressing her life and work, associating them with the historical context in which she lived. In the field of neuroscience, this article addresses her works on the structure and function of the hypothalamus, its sexually dimorphic nuclei, the association with sex hormones, and its association with the third ventricle, as well as the studies on the corpus callosum. Regarding feminism, we shall focus on her critical view of official science and the repercussions of this attitude.

Development

Early years: the East Coast

Ruth Harriet Bleier was born on 17 November 1923 into a family of Jewish origin.[1] She was the only child of the Hungarian pharmacist Abe H. Bleier and his wife Sadie Sima Bleier, daughter of Russian emigrants. She was born and raised in New Kensington, a suburb of Pittsburgh. There, she completed her primary and secondary education at state schools. In 1945, she graduated in political sciences from Goucher College in Baltimore, and subsequently studied for a medical degree at the Woman's Medical College of Pennsylvania, receiving her doctorate in 1949.[2,3]

Throughout her career, she was strongly committed to social justice and politics, actively fighting to achieve equal opportunities for all. As a medical student and intern, she was an active member of the Association of Internes and Medical Students, becoming its executive secretary. This pacifist organisation, founded in 1941, aimed to reduce and put an end to discrimination in medical education and practice and in healthcare services. The persecution of the organisation under McCarthyism and by the American Medical Association led to its disappearance in 1952.[2,4,5]

Ruth married the child psychiatrist Leon Eisenberg in 1949, and the couple divorced in 1966. The couple had two children, born in 1952 and 1956.[3] Eisenberg was a close collaborator of Leo Kanner in the study of autism in children, and succeeded him as chair at the Johns Hopkins University in Baltimore.[6]

Bleier completed a medical internship at Sinai Hospital in Baltimore in 1949-1951. There, she continued fighting against discrimination in medicine and politics. As an activist in the civil rights movement and leader of the Maryland Committee for Peace, she advocated for the end of the Korean War and the prohibition of atomic weapons. With this aim, in September 1950 the committee sent a letter signed by Ruth Bleier to the Soviet and American delegations of the United Nations Security Council.[7] Due to her political activity during the McCarthy years, at the

age of 27, her name appeared on the blacklist of J. Edgar Hoover, and in July 1951, she was called to testify before the House Committee on Un-American Activities of the United States House of Representatives. During the hearing, she refused to cooperate with the committee and made a statement in favour of peace and justice. She was accused of performing communist activities, while her husband worked at a military hospital in Washington.[2,3,8]

As a consequence of this process, she was denied the licence to work at Sinai Hospital and her membership of the Baltimore City Medical Society. After her conflict with McCarthyism, between 1951 and 1957, she practised general medicine in a depressed, racially mixed, working-class area of inner-city Baltimore.[2,9]

In 1957, she joined the laboratory of professor Jerzy Rose at the Johns Hopkins University School of Medicine for postdoctoral training in neuroanatomy, which she completed in 1961. Over the next six years, she worked as a research instructor in psychiatry and physiology at the Adolph Meyer Laboratory of Neuroanatomy of the same university.[10]

University of Wisconsin-Madison

After a brief stay as guest scientist at the Perinatal Physiology Laboratory of the University of Puerto Rico, in 1967 she began to work as a professor and researcher at the department of Neurophysiology of the University of Wisconsin in Madison, where Jerzy Rose had already been working since 1959.[11] She also worked at the Waisman Center on Mental Retardation and Human Development and the Wisconsin Regional Primate Center. Furthermore, she participated as a professor and researcher in the Neuroscience Training Program, founded in 1971 (Figure 1).[3,4,10]

In the 1960s, Bleier was active in the civil rights movement, and in the late 1970s she focused on feminism, fighting to improve the role of women in higher education. In 1970, at the University of Wisconsin, she was one of the founders of the Association of Faculty Women, a campus group that fought against gender inequalities between professors, achieving equal pay for women working at the university. She promoted women's athletics and also managed to introduce women to the gymnasium by providing them with decent dressing rooms and showers, which had been exclusive to men until then; she also created the Women's Studies Program in 1975, in which she worked as professor until her death. Bleier was a great music and sports enthusiast. She rode miles on her bicycle and swam long distances in Lake Mendota, close to the university area, even in the autumn months. She looked younger than her age.[4,9,10]

Her international leadership as a feminist scientist extended beyond the University of Wisconsin. In the early 1970s, with her colleagues Judith Leavitt and Marjorie Klein, she was a lecturer in the interdisciplinary course "The biology and psychology of women," within the experimental Contemporary Trends programme, and later within the Women's Studies Program, which she directed between 1982 and 1986. During this period, she significantly expanded the teaching curriculum, including African-American studies and anthropology courses on minorities and third-world countries, as well as the curriculum on women's studies. She promoted links between the university campus and the community and efforts to increase the proportion of faculty and students from minorities on campus, and pressured the university administration to get involved in women's studies. She organised activities in the community, where she helped to create Lysistrata, a feminist restaurant, and supported A Room of One's Own, a feminist bookstore. She fought for abortion rights with her partner, the physician Elizabeth Kalin, who performed abortions. In a time of separation of the growing lesbian movement from feminism, Bleier, herself a lesbian, rejected this model, acting as a bridge between lesbian and heterosexual women. From 1982, she also promoted the October 29th Group at the University of Wisconsin, a group dedicated to defending the role of the feminist critique of science.[12]

A month before her death, on 4 December 1987, her last work was presented at the Women's Studies Research Center of the University of Wisconsin-Madison. This work was conceived in the spring of 1987, as part of a series of lectures held to celebrate the centre's 10th anniversary. In the summer of 1987, she was diagnosed with cancer. The treatment for her disease, including surgery, and her professional duties prevented her from beginning work on the text until autumn. She was half-way through writing the draft when she was hospitalised again. Despite the pain and distress, she completed the work, writing by hand with the help of her friends. Judith Leavitt read the lecture, and Ruth Bleier later listened to the tape recording. Bleier died at home on 4 January 1988, after a hard fight against cancer. Her disease represented a severe blow to the community.[10] In December 1987, she had also presented a work on the

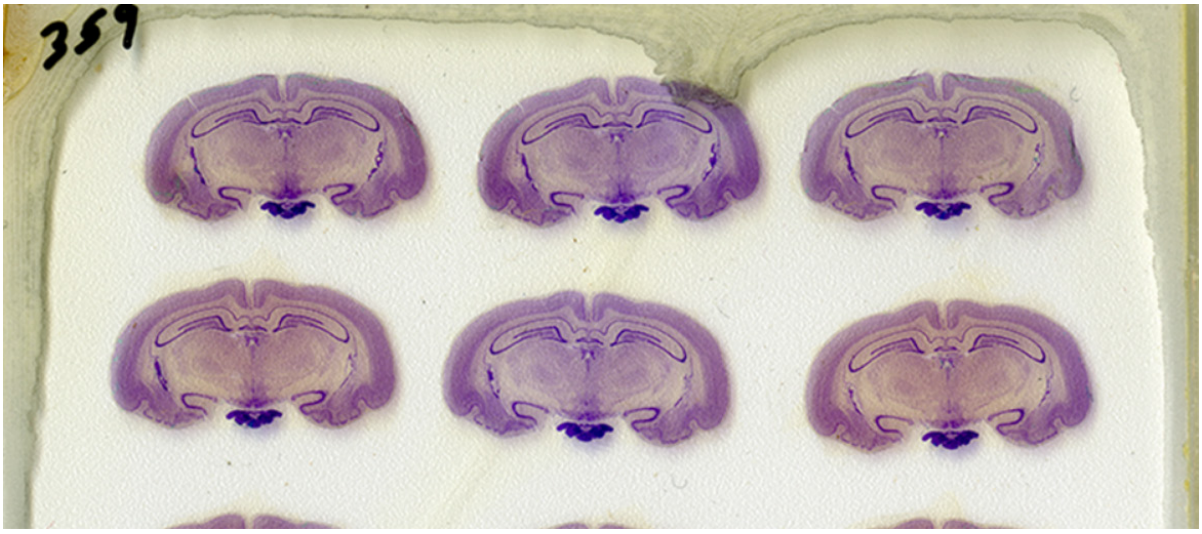

Figure 2. Multiple frontal sections of a guinea pig's brain.

exclusion of women from science at a meeting of the American Historical Association.[13]

Research on the hypothalamus

In her neuroscientific career, Ruth Bleier focused on the study of the structure and function of the hypothalamus, becoming an international authority on these topics. Her atlases with structural details of five animal species were of excellent quality and became fundamental for researchers on animal behaviour, neuroendocrinology, and neurophysiology in general.[4,9] In 1961, she presented the cytoarchitectonic atlas of the cat,[14] and atlases on the mouse in 1974,[15] the rat in 1979,[16] the guinea pig in 1983 (Figure 2)[17], and the rhesus monkey in 1984,[18] as well as a study on the septum and hypothalamus of the rat in 1985.[19] In these works, she presented the structural organisation and the known functional characteristics of the different areas of the hypothalamus. In the case of the guinea pig, she even described the sexual dimorphism in some areas and the unusually large extension of its magnocellular system.[17,20] In the atlas dedicated to the rhesus monkey, she provided experimental data from research on primates, frequently supplemented with data from the study of rats when needed due to the lack of data from primates, and highlighting the findings of greatest clinical relevance.[18,20]

In the 1960s, in addition to the hypothalamus of the cat, Ruth Bleier worked with Philip Bard and Jerry Woods to perform functional studies on hypothalamic cats (forebrain sectioned above the hypothalamus), achieving prolonged survival. Performing a high transection of the midbrain, they observed that all cell types, with the exception of cells of the medial mammillary nucleus, remained intact for long periods of time. In that time, there was abundant information on the role of the hypothalamus in autonomic and endocrine function, but its connections with the rest of the forebrain and the brainstem were still poorly understood.[21,22]

These researchers' success in achieving prolonged survival times unquestionably depended on the presence in each animal of an isolated portion of tissue including the hypothalamus and pituitary gland, whose only connection with the rest of the body was vascular, which would help to maintain a normal water balance and ensure adequate hormone release. They located the osmoreceptor region in the most rostroventral portion of the hypothalamus, connected with the pituitary gland. To maintain water balance, only a thin layer of

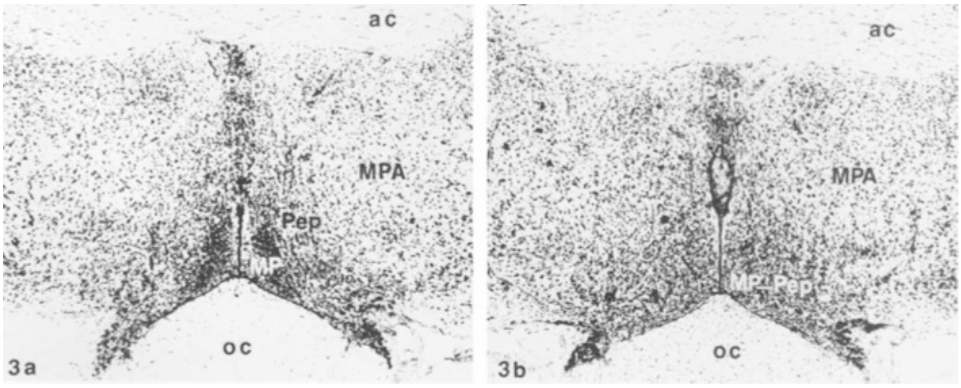

Figure 3. Anteroventral periventricular (AVPV) nucleus of the guinea pig. Differences are observed in the size and cell density and distribution of the APVP, labelled MP (medial preoptic nucleus) in the figure. Image 3a, from a female guinea pig, is more defined and displays greater cell density, whereas in image 3b, from a male animal, the nucleus is poorly defined and the preventricular portion of the periventricular nucleus (Pep) cannot be distinguished.[40]

hypothalamic tissue had to be maintained adjacent to the optic chiasm, extending along the ventral wall and the pituitary stalk.[23,24] Bleier's experiments with cats also suggested that the posterior hypothalamus was an important site for the integration and transmission of neural activity associated with thermoregulation. With ablation of this area, animals lost the ability to maintain body temperature when they were exposed to the cold.[22]

In 1969, Ruth Bleier studied the characteristics of the retrograde synaptic degeneration that occurs in the mammillary nuclei and ventral tegmental nucleus after limbic decortication in rabbits of different ages. Neuronal loss was complete in newborns, and decreased in animals in which the lesion was caused at older ages, with only a mild loss in adult rabbits. Damage particularly affected the medial mammillary nuclei, in which some neurons showed hypertrophy, with an increase in the number of synaptic contacts with neurons of the ventral tegmental nucleus. The medial mammillary neurons are a group of neurons with high susceptibility to direct damage to their axons, to which they react with severe retrograde degeneration. They are highly sensitive to the destruction of the anterior thalamic nuclei and of the limbic cortex, which is the central projection area of these nuclei.[25]

In 1974, Bleier and Hanna Sobkowicz (1931-2018), wife of Jerzy Rose,[11] studied the development in cultures of the mammillary region of newborn mice, which could survive up to 50 days. The survival of the neuron groups, the new growth of nerve cells, and the preservation of cellular architectonics, enabling their identification in the culture, indicated that the mammillary complex has a capacity for regeneration during its development in isolation.[26] Despite the complete loss of extramammillary influx, neurons survived and the mammillary tracts were preserved, with new growth sprouts at the point of the axonal transection. They established a new organisation of fibres, which grew around and richly ramified only within the nucleus or nuclear groups from which they are derived.[27]

Ependyma of the third ventricle

In 1971, Bleier suggested that the ependymal system of the third ventricle played an important role in the anatomical and functional organisation of the hypothalamus in different animal species. Tanycytes, a type of neuroglial ependymal cells, have a variety of structural forms and are intricately associated with hypothalamic neurons and capillary vessels. Bleier suggested that these cells work as

a system for communication between the cerebrospinal fluid of the third ventricle and the neurons and capillary vessels of the medial hypothalamus, participating in the regulation of the anterior pituitary gland.[28-30] She also described an intraventricular neuronal complex that protrudes to the ependymal surface of the lamina terminalis of the mouse, to which she attributed a role in the neurohormonal regulatory systems of the hypothalamus and pituitary gland or in mediating angiotensin effects.[31]

Bleier also studied the cells of the hypothalamic ependymal surface of the third ventricle in rodents, and its equivalent in lizards. These cells, with macrophagic properties, represent a resident phagocytic system and remove cell detritus and such external particles as latex beads, and the mumps and aphthous stomatitis viruses. This was a first defence in the cerebrospinal fluid against such external agents as viruses, preventing encephalitis, although persistence of the viral antigen inside cells may stimulate the formation of antibodies to favour prolonged states of immunity, but also damage oligodendroglia and myelin membranes.[32-37]

She also studied mouse ependymal and supraependymal cells in different stages of the oestrous cycle, observing that they presented significant variations reflecting the metabolic state of the animal; this suggests a dynamic relationship between the ependyma and the cerebrospinal fluid.[38]

Hypothalamic sexual dimorphism

Since the 1970s, sex differences have been described in different areas of the brain, especially in the hypothalamus of rodents. Ruth Bleier had a very active role in this area of research, studying the median preoptic nucleus and anterior hypothalamic area in the rat, mouse, hamster, and especially in the guinea pig. These areas had been shown to be involved in the regulation of sexually differentiated behaviours and reproductive endocrine functions. Ruth Bleier, together with Bill Byne and Inge Siggelkow, observed a sexual dimorphism regarding cell density and distribution in two components of the medial preoptic area of the guinea pig. The first is an anteriorly located compact subnucleus, which they called medial preoptic nucleus. This nucleus, which is twice as large in females, is now known as the anteroventral periventricular (AVPV) nucleus (Figure 3). The second area is a centrally located nucleus, larger in males, which corresponds with the sexually dimorphic nucleus of the preoptic area of the rat, which had been described in 1978 by Roger Gorski (1935-2021) and colleagues.[39] Sex differences were also observed in portions of the bed nucleus of the stria terminalis, which were more prominent in males.[40-43] The AVPV nucleus is especially rich in kisspeptin receptors, a neuropeptide discovered in 1996 that is important in peripubertal development and adult reproductive function.[44]

Sexually dimorphic cell groups within the medial preoptic area can be distinguished from the surrounding groups by the pattern of neurogenesis, as sex differences appear after onset of fetal gonadal activity. These sex differences were not affected by neonatal gonadectomy or postnatal hormone manipulation, but females exposed to testosterone during the fetal period presented differences in nuclear morphology and sexual behaviour, suggesting that dimorphism in these nuclei was insufficient to establish differences in the functions of the medial preoptic area, and that the hormonal milieu continued exerting organisational influences on the development of the brain after cytoarchitectural patterns had already been determined.[41,42]

In addition to the discoveries in rodents, sexual dimorphism associated with the volume of preoptic nuclei has also been described in other species, including sheep, ferrets, rhesus monkeys, and humans.[43] Findings in these species cannot be automatically extrapolated to humans and other primates, or to complex behaviours of social species in which learning and environment affect behaviour and the development of the brain.[40]

Bill Byne, who had worked with Ruth Bleier in her research on the preoptic area of the hypothalamus of rodents, continued this research in humans in the 1990s in New York. Previously, in 1989, Laura Allen and Roger Gorski had discovered a sexual dimorphism in the interstitial nuclei of the anterior hypothalamus (INAH-1-4) of humans, discovering that the INAH-2 and INAH-3 nuclei were larger in men.[45] Subsequently, in 1991, Simon LeVay studied patients who had died due to AIDS, reporting that the INAH-3 nucleus presented greater volume and more neurons in heterosexual men that in heterosexual women, and was also larger than in homosexual men.[46] Byne et al.[47] confirmed the dimorphism in the volume of the INAH-3 nucleus, with heterosexual men presenting greater volume and larger numbers of cells than in women, and a larger size than

Figure 4. Ruth Bleier in 1980. Source: UW Digital Collections.

in homosexual men, although with no differences in the number of cells. Furthermore, the INAH-4 nucleus was larger in both groups of men than in women. Nevertheless, they admitted that sexual orientation could not be reliably predicted according to the volume of the INAH-3 nucleus.[47] Speculations have also been made regarding variations in this nucleus in transsexual people. Further studies are needed to clarify these questions (Figure 4).[48,49]

Corpus callosum

In 1982, the journal *Science* published an article by Christine de Lacoste-Utamsing and Ralph Halloway[50] on the sexual dimorphism of the corpus callosum. These authors believed that they were the first to discover an actual sex difference in the human brain, associated both with cerebral lateralisation and with cognitive functions. They suggested that the larger splenium observed in women suggested decreased cerebral lateralisation or specialisation for visuospatial functions, compared to men. This study presented methodological and conceptual shortcomings and was exclusively based on autopsy studies of 14 brains. Bleier, Byne, and Lanning Houston used magnetic resonance imaging to repeat all the measurements from the original study, adding several other parameters, and found no significant differences.[51,52] They sent the work to *Science*, which rejected the article, as they had already done with a previous article by Ruth Bleier. She complained of the journal's lack of interest in scientific works from a feminist perspective and engaged in a polemic with its editor Daniel Kohland, who eventually apologised.[10]

In their research, Bleier and her colleagues used magnetic resonance imaging to measure the corpus

callosum of 37 living subjects (15 men and 22 women), finding no significant differences in the splenium. They found a difference in the minimum width of the corpus callosum, which was greater in women, and a smaller anteroposterior distance in subjects older than 40 years. More surprising were the considerable differences in the size and shape of the corpus callosum, which prevented the researchers from establishing correlations between these variations or with cognitive function. These findings suggest that the postnatal maturation of this brain structure is significantly influenced by motor and sensory experience, as well as other environmental factors.[51,52]

In 1997, Bishop and Wahlsen conducted a meta-analysis of 49 studies performed from 1980, most of which used magnetic resonance imaging, and observed no significant differences between men and women in the size or shape of the splenium of the corpus callosum.[53]

The dominant theory among the scientific community of the time was that men process visuospatial information in the right hemisphere, or in a more lateralised way, whereas women used both hemispheres, more symmetrically. For this reason, men were considered to have superior visuospatial abilities. Even if these sex differences in the lateralisation of hemispheres or visuospatial function could be demonstrated, there was no evidence supporting a correlation between the two phenomena. Bleier indicated numerous methodological weaknesses in this field.[51]

Feminist critique of science

Ruth Bleier was a left-wing political activist from her student years in the 1940s until the second half of the 1960s, when she began to rebel against the university administration and organised women at the University of Wisconsin. As a neuroanatomist and neurophysiologist, she was accustomed to observing reality through the microscope, and worked with a special area of the brain, the hypothalamus, probably the area showing the most sex differences, and which presents anatomical and functional connections with the pituitary gland, which regulates the function of endocrine glands including the ovaries and testes and which supposedly controls reproductive functions, conditioning sex dimorphism in the brain.[10,54]

By the time of her death, she was internationally renowned as a pioneer in the examination and critique of sex bias in the scientific research of sex differences and the nature of women. She was one of the few female laboratory researchers to analyse scientific institutions, theories, and methodologies from a feminist perspective. Her two books, *Science and gender*[55] (Figure 5) and the anthology *Feminist approaches to science,*[56] as well as numerous articles on the sex bias in scientific research, led her to be seen as the leader of the feminist critique of science.[10,13,57-60] She described how, in a wide range of scientific fields including sociobiology, neurophysiology, anthropology, primatology, and transcultural studies, the pre-existing biological deterministic ideas on the inferiority of women determined the research, the observation of data, and the conclusions of official science, an institution that reflects the norms of the society in which it develops.[4,55,61]

Her first feminist book including a critical analysis was *Science and gender*,[55] published in 1984, which was soon followed by works by Anne Fausto-Sterling (1944-),[62] Evelyn Fox-Keller (1936-),[63] and Sandra Harding (1935-).[64] Of these four authors, Bleier and Fausto-Sterling, both distinguished professionals in the field of biological sciences, presented their critiques in the context of science, whereas the other two, philosophers of science, focused on the context of philosophy and psychology. All four conceive nature and gender architecture in nature as a construction of the male mind, of the way men think and practice science, concerned with establishing sex differences and the inferiority of women. The most powerful area in which attempts had been made to demonstrate the inferiority of women was her own field of research, neurosciences, in which research was conducted on sex differences in the structure and function of the brain that underlie the alleged differences in cognitive capacities.[10,54] Sandra Harding describes the works by such researchers as Bleier and Fausto-Sterling as "spontaneous feminist empiricism." By this, she meant that they are scientists who critique other scientists, but when doing so, they share a series of basic beliefs on what constitutes good scientific praxis. They tried to identify areas in which prevalent androcentric and sex biases in society influenced scientific work. Furthermore, they consider that these biases can be corrected through strict adherence to the traditional methodological canons of scientific research.[64]

Feminist scientists assert that research on sex differences is comfortably established within an androcentric

conceptual framework that has historically aimed to consider inferior anything genetically or biologically linked to female sex and to support male superiority in behaviour and abilities, considering the distinction between pure genetics and the environment to be significant and sustainable, and assuming that genetics explains human behaviour. The feminist position is based on the concept that biology is both a genetic and a cultural concept and that the question of biological sex differences between men and women is conceptually weak if the assertion is made that biology is separate from culture, the environment, and learning, and that any differences in the behaviour of men and women are based purely on biology.[55,65]

In *Science and gender*, Bleier describes the role of science in the creation of a mythology based on the biological inferiority of women as an explanation for their subordinate position in the cultures of Western civilisation. Her arguments are based on empirical analysis, and she points out that many of the studies claiming to demonstrate or explain differences between women and men are methodologically or conceptually flawed or inconclusive. Neuroscientific research has a central position in her critiques of official biology. Brain development depends on stimuli from the outside world, which makes it impossible to separate the concepts of biology and culture. She does not deny the existence of biological components in human behaviour, "but for each person, brain-body-mind-behaviours-environment form a complex entity the parts of which are inextricable from each other; the parts and the whole are ceaselessly interacting and changing and carry within themselves the entire history of their interactions."[55]

Androgen research on rodents has served as the model for biological determinists who attribute sex differences in social roles and behaviours to the early organising effects of androgens on the brains of human males. Giving androgens to newborn female rats increases their mounting behaviour and fighting behaviour as adults; castrating newborn male rats has the opposite effect. As a result, researchers concluded that androgens exert an organising effect on the developing brain that determines subsequent adult behaviour.[57] The general interpretation of these works suggests that the effect of androgens on the developing human fetal brain will lead to aggressivity and dominance, intelligence, tomboyism, lesbianism, and male gender identity. The absence of the effects of androgens on the developing female brain would explain

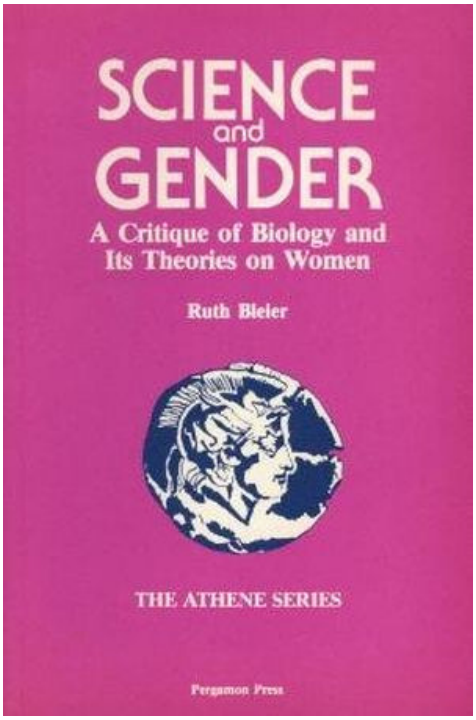

Figure 5. *Science and gender*, 1984.[55]

the female characteristics of passivity, compliance, and inferiority. Inadequate amounts of androgens in the developing male fetal brain will subsequently lead to homosexuality or confused gender identity.[55]

Bleier asserted that research in humans and other primates had failed to show the organising effects observed in rodents. Furthermore, subsequent studies showed that the hypothesis that androgens masculinise the brain is excessively simplistic, and that it is not possible to clearly distinguish between the effects of oestrogens, progestogens, and androgens, as all of them are produced by both males and females, and follow multiple metabolic pathways. In general, she argued that findings from those studies were extrapolated too quickly to other species.[55]

Primates have been the other preferred animal model of sociobiologists to identify sex differences, although, once more, it is difficult to extrapolate their behaviour to humans. The study of these animals also presents an androcentric bias. The favourite model is the large alpha

male who is the first to choose food and sexual partners from the group. Primatologists and anthropologists assume that dominance hierarchies among non-human primates are universal and masculine. The human brain presents more complex functions that afford it a behavioural plasticity different to stereotyped behavioural patterns. Manifestations of cortical functions cannot be segregated from the social and cultural environment that defines human behaviour.[10,57] In this field, the growth in the number of female primatologists from the late 1960s led to a paradigm shift, establishing that many groups lacked hierarchies or that, when these did exist, they involved both males and females and were not directly associated with strength, age, or reproductive success.[13] Bleier underscores the futility of attempting to separate the structural and hormonal aspects of social learning from the environmental influences in brain development. She suggests that fetal and postnatal development shows high levels of plasticity that make the brain sensitive to experience.[55]

As previously mentioned, Ruth Bleier also addresses sex differences in brain lateralisation in humans, suggesting that the disagreements between psychological studies assessing verbal and visuospatial skills and those analysing differences in lateralisation between men and women are not consistent; she also considers the relationship between the degree of lateralisation and the performance of specific psychological tasks to be weak. Bleier argues that the association between a higher degree of lateralisation in men and their supposedly superior visuospatial and mathematical abilities is based on circular reasoning.[55,56] As we do not know what mechanism or cerebral structures and processes explain verbal fluency, mathematical skills, intelligence, or the great variety of differences in a given population of individuals, we are unable to explain sex differences in these processes.[56]

Conclusions

The life of Ruth Bleier was intense, and perhaps too short to satisfy all her interests as a neuroscientist, social activist, feminist, advocate of multiple causes, and polemist.

She was recognised as a distinguished specialist in the anatomy and physiology of a significant area of the brain, the hypothalamus, of which she created atlases for different animal species. These atlases were an important reference for researchers from her own and from later generations. She also studied the behaviour of this part of the brain after isolating it from other cerebral structures, as well as sexual dimorphism in some of its areas. Furthermore, she focused on the ependyma of the third ventricle and its cells, especially neuroglial cells, tanycytes, and supraependymal macrophages, which are essential in fighting central nervous system infections.

She fought against the androcentrism that dominated the official science of her time, and criticised the alleged sex differences in the morphology of the corpus callosum and the studies that reported differences in hemispheric lateralisation and the visuospatial skills between men and women.

Her feminist activism also led her to fight for improvements for women and minorities at the university, and in the relationship between the campus and the community. She created a strong women's studies department at the University of Wisconsin-Madison, which was a role model in the fight for equality. Her modern message is surprising, considering that we will soon be celebrating the centenary of her birth.

Conflicts of interest

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