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Marian Smoluchowski

WOMEN IN EXACT SCIENCES A LECTURE DELIVERED AT THE SCIENTIFIC-LITERARY ASSOCIATION IN LWÓW IN THE YEAR 1912

An old-fashioned man who might have turned up at this present gathering would be pretty astonished by the very choice of the subject-matter it falls to my lot to talk about. 'Women in exact sciences'? Why, until the most recent time they would never deal with such sciences at all, and the contribution of women to the development of exact sciences is negligibly small. It was on this that one of the main arguments meant to prove the alleged intellectual inferiority of women was essentially based. They never deal with mathematics, or physics, or chemistry, for they are incapable of this, since they cannot think logically at all! Arts, literature, can be approachable for them; but sciences, which, above all the others, require a mathematical strictness of thinking and boasting of the name of exact sciences, these sciences will always remain alien to them.

To-day, the general public's view of this particular matter has altered considerably. The dogma of a fundamental illogicality of female mind has been removed to the stock of old prejudices. There is, probably, a considerable number of women who would say, as Sienkiewicz tells us, that two plus two makes a lamp;[1] but ever since the secondary schools, and also, partly, tertiary schools, opened for women, and since their level of education has generally approached the male counterpart, it has been observed with astonishment that women are able to think quite well, once they have been through appropriate grounding, and if they are willing to do so.

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[1] Henryk Sienkiewicz (1846–1916), Polish writer and journalist, Nobel Prize Laureate in Literature (1905). His historical novels were extremely popular among Poles. Smoluchowski touches upon the problem of historical female figures (particularly from the seventeenth century) portrayed and perceived as submissive, deprived of will.

Female graduates of our grammar schools [*gimnazjum*s] are knowledgeable not any less and not any more of the sinuses, cosines, logarithms, than the boys do; at universities, they also attend lectures on higher mathematics, physics, chemistry, and this with an equal effect. The professors who have gained experience in this regard ascertain that female students might even outpace their male peers in the wittiness of comprehension, conscientious diligence, and easiness of absorption of the content, whilst in another regard, as far as independence of thinking is concerned, men are positioned higher. …

There is thus no doubt, and everybody must admit this to-day, that there is a considerable number amongst women, perhaps not lesser than amongst men, of such who are capable of obtaining thorough education in the field of exact sciences and who are able to embrace the entire domain and the whole depth of these sciences. They are capable of learning as well as to teach the others; there comes to mind one more issue (and we shall chiefly be dealing with it at the moment): are they capable of independently creatively work as scholars, and can they parallel men in scientific productivity?

That things appear different in this particular respect is undisputable. Applicable to this are the words uttered at the beginning, whereby until very recently the merits of women around the progress of exact had almost equalled zero. Even to-day, women's scientific productivity, except for one case that shall be discussed further on, is *une quantité négligeable* in regard of these sciences, albeit their creative output in literature, arts, and poetry occupies a place so reputable, oftentimes first-rate.

Doubtlessly, quite a number of names of female scholars who have created works of a certain scientific value. … One could point to Ms. Agnes Pockels,[2] … or Ms. Lisa Meitner,[3] who works in the field

[2] Agnes Pockles (1862–1935) was a German physicist and chemist, sister of Frederic Pockles, who was professor of physics in Heidelberg. She established a new discipline of chemistry, called surface science.

[3] Lisa Meitner (1878–1968) was an Austrian physicist, assistant to Max Planck. In 1909 she presented two papers on beta-radiation. In 1912 the research group moved to the newly founded Kaiser-Wilhelm-Institute in Berlin-Dahlem, where Meitner worked without salary at the Department of Radiochemistry. For more, see Annette Vogt, *Vom Hintereingang zum Hauptportal?: Lise Meitner und ihre Kolleginnen an der Berliner Universität und in der Kaiser-Wilhelm-Gesellschaft* (Stuttgart, 2007); Annette Vogt and Renate Tobies (eds.), *Women in Industrial Research* (Stuttgart, 2014).

of radioactivity; several other names could most probably be added from the fields of mathematics, chemistry, or astronomy.

One has to admit, however, that these names have stuck in our memory just because of the very fact that they are all women, whilst the scientific contribution yielded by those authoresses is in itself so tiny that is perishes in the flood of labours equally important or incomparably more important, which were performed and are being performed by the other scholars.

In order not to rely exclusively upon my own subjective judgment, let me now refer to [Felix] Auerbach's *Geschichtstafeln der Physik*,[4] containing an enumeration of all the important discoveries and studies in the field of physics and its related sciences: I cannot find any of those names there. Amongst more than 1,300 names mentioned, merely three belong to women; I reckon that, in essence, these very three names have an importance higher than ephemeral in the history of exact sciences; it namely befits for us to deal with them somewhat more detailed fashion, if we are willing to establish an opinion regarding the substantial merits of female scholars.

These include: Mademoiselle Sophie Germain, Sof'ja Kovalevskaja, and Marie Curie, née Skłodowska. Mademoiselle Sophie Germain[5] is known in theoretical physics as the one who has authored the famous study on vibrations of elastic plates, which, albeit it appeared erroneous at a later date, had a bearing on the progress of science all the same. In order to make the subject of these studies even clearer, let me remind you of the impressive experiments in which elastic plates – for instance, round or square-shaped chunks of thick brass sheet-metal, fixed on an appropriate tripod – become induced to produce transverse vibration, as by gliding a violin bow at one point of the edge. If we pour a small amount of sand on such a plate, then the vibrations arrange it into nice regular figures whose shape is determined by the shape of the plate and the method with use of which the plate is incited to

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[4] Felix von Auerbach, *Geschichtstafeln der Physik* (Leipzig, 1910).

[5] Sophie Germain (1776–1831) was a French mathematician and physicist. She studied mathematics and physics on her own. Her interests encompassed number theory and elasticity theory. She exchanged scientific letters with the outstanding mathematicians Joseph Louis Lagrange, Adrien-Marie Legendre, and Carl Gauss. She hid her sex under a male nickname of 'Chevalier La Blanc', but finally all her correspondents learned that she was a woman. Sophie Germain obtained an honorary PhD from Göttingen University.

vibrate. The phenomenon was discovered by [Ernst] Chladni at the end of the eighteenth century; it was after him that they were named Chladni figures; these experiments, popularised through Chladni's works (1802) and his public lectures, acquired a wide resonance at the time in Germany and France.[6] Upon wish of Napoleon, who was engrossed by these experiments, the Paris Academy announced in 1809 a prize for the study which would theoretically explain these phenomena. The point was, therefore, about solving a mathematical problem: how is it that vibrations of such a plate occurs; and this was all the more difficult that the general mathematical theory of phenomena of elasticity was not known at the time yet. In the year 1811, Miss Germain submitted her study to the Academy; Lagrange, the famous mathematician, who sat at the judging Committee, discovered an error in the calculations, though. The study was presented to the Academy again in a revised form, and in the year 1815 the prize was awarded to the authoress, who meanwhile continued to complement her research on the topic. …

Back with the study by Miss Sophie Germain, it has to be admitted that this was a scientific deed, illustrious in the context of its time, and as such, in spite of the later criticism, maintains its commendable position in the history of mathematical physics. As regards the authoress' personality, I cannot give too many interesting details, for her life was not distinct with a variegation of occurrences, in a glaring opposition to the epoch it fell on: 1776 until 1831. … As it seems, there is nothing coincidental in fact that it is the tempest of the French revolution that the appearance of a personality as extraordinary as Miss Germain falls on.

She did not, however, pursue the track of those women who fought on barricades, on a par with men. On the contrary, she was scared with the turmoil of civil war in which her family also directly took part, as her father was a member *de l'Assemblée Constituante*. As a thirteen-year-old child, she assumed as her ideal Archimedes, who, thoughtful in his geometric searches, did not notice that the enemy had seized the besieged town and burst into his house. Ever since, despite her parents' resistance, she devoted herself to studying mathematical works, self-educating herself, often furtively spending her nights with a book … Miss Germain idolised harmony and order, in the

[6] Ernst Florens Friedrich Chladni, *Die Akustik* (Leipzig, 1802).

first place; she researched the principles of mathematics, admired the eternal order in the laws of nature, she longed for orderliness, harmony, and justice in social arrangements. Without even knowing any precise biographical facts, and only judging by Miss Germain's scientific activity, we recognise that she should be categorised as a mental type referred by [Friedrich Wilhelm] Ostwald[7] as 'classics', as opposed to 'romantics'. Is it not characteristic that in the course of seventeen years, she was continually occupied with the same, rather special issue; that she wrote five studies on the same subject, gradually correcting and complementing her studies; that she has not become famous owing to any other eminent work. What this testifies to is an inclination for strictly oriented continuous, patient, and meticulous endeavours, which many a man might envy.

A different intellectual type was the other earlier-named scholar, Sof'ja Kovalevskaja;[8] her intellectuality, revealing itself in science, was strictly associated with her composition as is known to us from biographies, from the letters and memoirs. An unstable character, mutable in its sympathies and antipathies, acting impulsively, often outright witlessly, without consideration; a disposition fluctuating between ecstasy and dejection; a mind extraordinarily bustling, zealously craving for everything it found absorbing and rousing, such as science, literature, socialism, freedom currents. As far as scientific research goes: is it not striking that the studies she has published, six[9] in total, refer to five most completely different and separate objects … .

How far Kovalevskaja's talent was appreciated by her contemporaries is attested by the obituary published in the *Neues Journal für Mathematik* by the famous German mathematician Kronecker, in which one reads:

> Her gift for general mathematical considerations was extraordinary; she had the indispensable ability to pursue specialist research, and was conscientious

[7] Walter Karl Wilhelm Ostwald (1886–1958) was a German chemist and philosopher, and a Noble Prize laureate.

[8] Sof'ja Kovalevskaja (1850–91), Russ. Софья Васильевна Ковалевская, was granted a regular doctorate, *summa cum laude*, from Göttingen University in 1874. In 1883 she obtained an academic position in Sweden and five year later she received an 'extraordinary professorship' and became the first woman to hold a chair at a European university.

[9] According to the journal *Jahrbuchüber die Fortschritte der Mathematik*, Kovalevskaja had eleven scientific papers – in partial differential equations, abelian integrals, astronomy, crystallography, and mechanics – published to her credit.

> and eminently industrious a person; whilst completely devoting herself to her scientific work, she did find leisure for other intellectual interests; she kept her femininity, and maintained contacts with individuals beyond her scientific circle, winning their sympathy. The history of mathematics has considered her an unusual personality amongst those few women ever dealing with this domain of science. The memory of her shall persist in the world of mathematics owing to her outstanding valuable scientific works, albeit she has had a few published.

As opposed to Sophia Germain, the intellectuality of Sof'ja Kovalevskaja enhances features of a romantic type (according to Ostwald): agility, or rather, boisterousness, of mind; sensitivity, intensity of short-lasting efforts. In order to avoid misunderstanding, I clearly remark that the word 'romanticism' only means here a certain intellectual predisposition, rather than sentimental romanticism in a common sense of the word. In this respect, on the contrary, the surviving writings and letters prove that Kovalevskaja, who got married only with the idea in mind to get away from the unbearable home relationships and to devote herself unrestrainedly to science, tried in vain during her entire lifetime to cognise what she called the *blue bird* and what oftentimes occupies a primary place in the life of women. It seems that she vividly sensed this want and that this was one of the tragedies of her life. As regards this particular facet of her life, a polemical literature appeared, thanks to Kovalevskaja's biographers who were interested in the events of her private life much more than her importance in science. A male scholar always appears almost impersonally, as an author of certain scientific works; it is by the value of these works that we assess his significance, regardless of any facets of his private life whatsoever. When it comes, though, to a female scholars, everyone appears interested in her private life, above all, which nowise translates into the evaluation of her scientific merits; see how easy it is to cast suspicions having nothing to do and yet injurious in the public's eyes.[10] …

Should death had not put an end to her activity so prematurely, Kovalevskaja's role in to-day's mathematics and theoretical physics would have doubtlessly been more momentous. Within the seven

[10] A year before Smoluchowski's lecture, it was revealed that in 1910–11 Marie Curie (born Maria Skłodowska) had had a love affair with the physicist Paul Langevin, who was a married man. This resulted in a press scandal. She was misrepresented in the tabloids as a foreign Jewish home-wrecker.

years of her professorship, she gives evidence to her unusual aptitude, strokes of genius; but these are rather trivial things, she did not manage to create any new domains of knowledge, to open new ways of progress for research in science, with which she was probably talented ahead of all the other women.

As regards general scientific importance, the activity of our compatriot, Mrs. Curie-Skłodowska, to whom I am now passing on, is doubtlessly much weightier in effects. The name has acquired to-day a renown any other female scholars ever enjoyed; it will, moreover, be without doubt firmly recorded at an outstanding place in the history of physics and chemistry.

It is hard to shortly provide an outline, be it a superficial one, of the activities of Mrs. Curie-Skłodowska; it is a domain of novel, and unusual, phenomena; how extensive the material amassed in this field is, is attested by the volume of Mrs. Curie's work *Traité de radioactivité*; in two volumes, the content totalling just below 1,000 pages. … In an attempt to characterise the intellectual type of Mrs. Curie-Skłodowska's labour, according to the apt classification of Ostwald, she is, to my mind, an outstanding representative of the classic type (similarly as her husband). Strict logical reasoning, methodical and assiduous work, with a clearly defined direction, satisfaction in precise finishing of research, carefulness in formulating hypotheses and conclusions are all extraordinarily characteristic features, rendering her distinct from, for example, Sir J. J. Thomson, Sir E. Rutherford, Sir William Ramsay, who were all typical romantics.

The momentousness of the research of the Curies for science calls for no explanation. They have developed the foundation for the science of radioactivity, which has to-day become an autonomous branch of science, intermediate between chemistry and physics; a science that has shed a new unexpected light on both of these crafts. Let me mention, by the way, that the studies of Sir E. Rutherford have stated the legitimacy of the theory of transformation of atoms, which was proclaimed as a hypothesis by Mrs. Curie already in 1899; according to this view, atoms of radioactive elements are not unchangeable but grew old and brittle with time, and the falling-off crumbs are α and β rays, composed of particles ejected by the atoms at enormous speed. As we also know to-day, polonium is a descendant, or product, of the transformation of the atoms of radium, whilst the latter is, in turn, probably a descendant of uranium. Of the subsequent stages of the

transformation, which chemically behave as elements – 'radioactive elements', in short – as many as thirty-five are presently known to us.

The point-of-departure for our deliberations was the issue of the female mind's aptitude in exact sciences. I have endeavoured to give a fair image of the scientific activity of three female scholars; this suffices to confute the prejudice whereby women be incapable at all of working creatively in respect of these sciences. The scientific merits of our compatriot might be envied. It thus seems even more weird that these are but very rare exceptions; why to this day there prevails an enormous disproportion in the labour of women and in the labour of men in the field of strictly scientific creative work, whereas women occupy eminent positions in literary, poetical, artistic output, and even within the confines of exact sciences they prove no inferior to men in reproductive activity: in learning and teaching others. The opinion is often heard that it is an effect of heredity, a consequence of age-old neglect of the female mind. It seems to me that such explanation does not withstand scrutiny. Each naturalist knows how extraordinarily stiffly the features acquired during an individual life get inherited. How many generations should pass one after the other for permanent psychical inclinations to be developed! Certainly, many more than the historical period of the male youth receiving systematic school education may embrace. After all, psychical (and, for the most part, physical) inclinations are not inherited in the way that the abilities of the father are passed on to the son whilst the abilities of the mother, to the daughter; the converse is true, too, with an equal degree of probability.

I do not think there appears any outstanding difference in the intellectual disposition of both sexes, and that the female mind may have a lesser capacity in the aspect that is absorbing us. The disproportion in question is rooted in certain reasons of a different nature; namely, the difference in inclination, the difference in the pursuit, and the difference in the character.

Exact sciences are normally less enticing to women than humanistic sciences; the sciences that Herbert Spencer described as 'ornamental'. By nature, women tend to have a propensity for ornamentativeness; and, they prefer history, literature, philosophy, or even medicine and biological sciences, rather than mathematics, physics, or chemistry. The former focus around man, around life; the latter deal with inanimate nature and abstract precepts; they prevalently seem dry and boring to women. Will these likings change with time? I do not suppose so.

Ignoring the difference in inclination, let us pass on to the psychology of scientific creativity; I reckon that also in this respect women are positioned less favourably. Creative work in science requires complete devotion to science, and thought focused in one direction. There, dilettantism is completely unacceptable; a scholar is always an eccentric, to an extent, with his eyes fixed on his science, one who ignores the other considerations and obligations of everyday life. Woman, for a change, is a bond-maid of petty daily duties. If she practices science, she usually does it other than with an intent to devote her entire life to it, but rather, in a dilettante manner.

In arts and, particularly, in literature, dilettantism is no obstacle in achieving grand results. This is impossible in science: there, one has to pass through years of demanding and systematic study, before being allowed to dream about independent work; those willing to attain serious results must nail their soul entirely to the altar of science. Although a considerable portion of 'learned' professions is open to women to-day (and it would be high time now for any limitations in this respect to disappear), a significant majority of women will always be busy doing the job in which, as J.S. Mill describes it, "man is incapable of rendering himself competitive against her".

Lastly, when it comes to women who have a bent for science and who dedicate themselves entirely to it, it is beyond any doubt that men usually distinguish themselves with more enterprise and independence. Rather than a property of mind, it is one of character; still, this property does exist, and plays a part that is immensely important in scientific creativity. There is a series of features that compose it: a sort of rashness, audacity in proposing one's opinion, obstinacy and self-trust, a rabidity in the ventures embarked on – all in all, the features of character we observe in boys fighting in the street. They were the reason for Columbus's success, and they are a source of inspiration for learned scholars in discovering new ways of scientific research; they are at the root of what we call ingeniousness.

It does not seem probable that a complete equality might ever prevail in the field of scientific creativity, though the present disproportion will, no doubt, be diminished with time. Women do display certain special advantages, including scrupulous conscientiousness and painstaking diligence in work, which should give them an outstanding ability in the field of chemistry, for that matter, where systematic and laborious experimental search plays an important role.

Those women who enter the scientific path should have their vocation facilitated; any and all external obstacles ought finally to be removed: those funny superstitions, those outdated views which obstruct women's access to some scientific institutions, rendering it difficult for them to study, pursue scientific work, obtain university chairs. May the free competition principle govern in this (as well as on any other) field. Let us wish for the competition to be as animated as practicable.

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