On gender, science and all that

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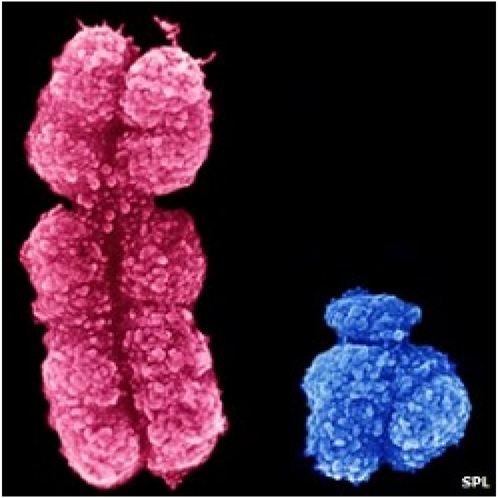
20th Workshop on String Theory

Mainz, September 25, 2014.



Overview

Everything began here

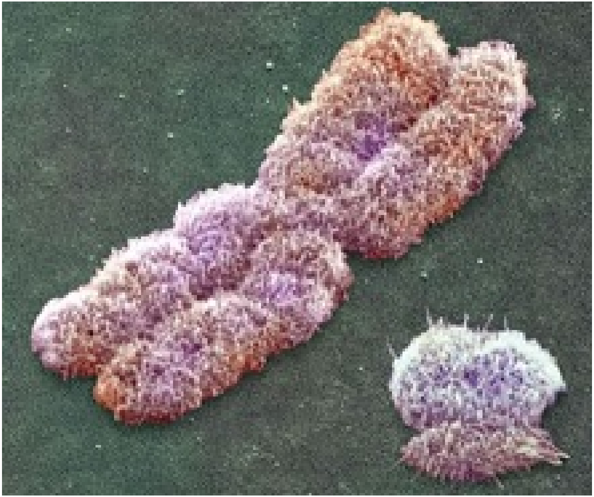
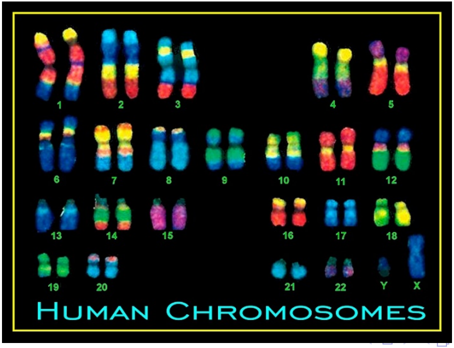


Figure : A scanning electron micrograph of human, sex determining chromosomes.

Human chromosomes

Human beings have 46 chromosomes arranged in 23 pairs. 22 pairs are formed by two *homologous chromosomes* (they have the same genes in the same positions). The last pair are the *sex chromosomes*.
Females have two homologous chromosomes (**X**) and males have an **X** chromosome and a different chromosome (**Y**).



Sex determination

During *meiosis* cells are produced that contain only one chromosome of each pair. These are the male and female *gametes*.
Female gametes have always an **X** chromosome while male gametes can have either **X** or **Y** chromosomes.

In fertilization, a male gamete and a female gamete merge to form a cell, the *zygote* that will have, again, 46 chromosomes organized in 23 pairs. From the zygote, a new individual grows.

If the father gamete contains a **Y** chromosome, then the child will be male. If it contains an **X** chromosome, then the child will be female.

Roughly, there is 50% probability that the offspring will be male or female.

Sex determination

The **Y** chromosome has a gene (**SRY**) which makes testes form in the fetus. Seven weeks after conception, the testes start producing testosterone and this causes the fetus to develop as a male. In the presence of two **X** chromosomes, the fetus goes on to form ovaries, which $\sim$ do not produce testosterone. The fetus then develops as a female.

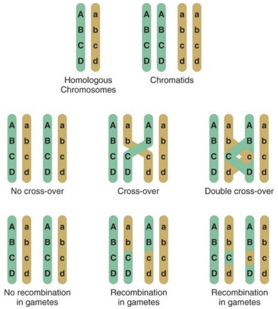
There are fossil records of sexual reproduction from 1200 million years ago. There are different contending theories on the origin and evolution of sexual reproduction.

Humans share with most mammals the sex determination mechanism that we have described here.

Evolution of the Y chromosome

X and **Y** chromosomes were originally standard homologous chromosomes. About 180 million years ago, a mammal ancestor developed the **SRY** gene in one of the chromosomes, which converted it into a **Y** chromosome.

Genetic recombination is the mechanism for which, during meiosis, homologous chromosomes exchange some pieces. Recombination prevents homologous genes to drift apart and helps to repair damaged DNA.

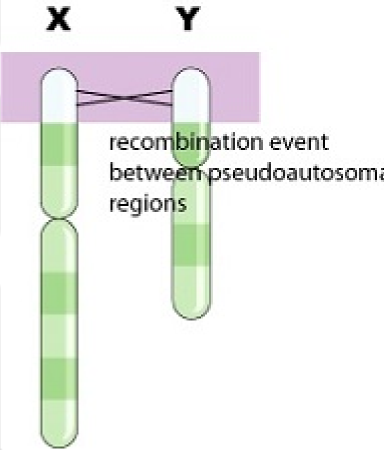


Evolution of the Y chromosome

Some genes useful for males and not useful (or damaging) for females developed in the **Y** chromosome.

Genetic recombination between **X** and **Y** could be harmful, because it could deprive males from those male-beneficial genes and give them to females.

Recombination was then largely inhibited and nowadays only a 5% of the **Y** chromosome recombines.
X genes, on the other hand, keep recombining in females.



Evolution of the Y chromosome

As a consequence of non recombination, natural selection cannot act on the individual genes of the **Y** chromosome. Deleterious genes are passed together with beneficial genes. This mechanism is inefficient.

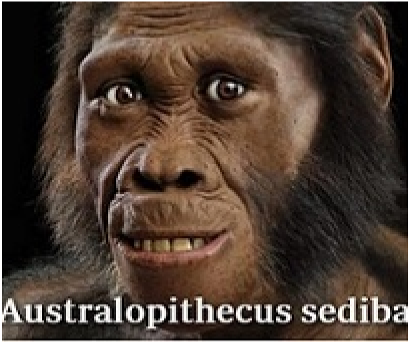
The **Y** chromosome started to lose genes. The human **Y** chromosome has lost ∼97% of its genes.

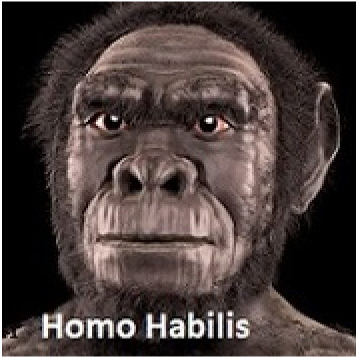
This is not harmful for males, since they also have the **X** chromosome, that can keep expressing the necessary proteins.

Non vital genes can reside in the **Y** chromosome, since it is absent in half of the population.

Inflation of brain size in hominids

The blatant feature in the evolution of hominids is the inflation of brain size. With *Homo Habilis* (1.9 million years ago) it reached ∼750cc. Researchers created the genus *Homo*, to which *Homo Sapiens* belong.





Brain size by itself is not a reliable estimation of cognitive abilities, but one can make appropriate corrections.
The brain is responsible for the functioning of the whole body, so it makes sense to consider the ratio

$$\text{Brain Mass }/\text{Body Mass.}$$

It makes sense to study these ratios in a group of similar species.

It does not say anything about individuals!

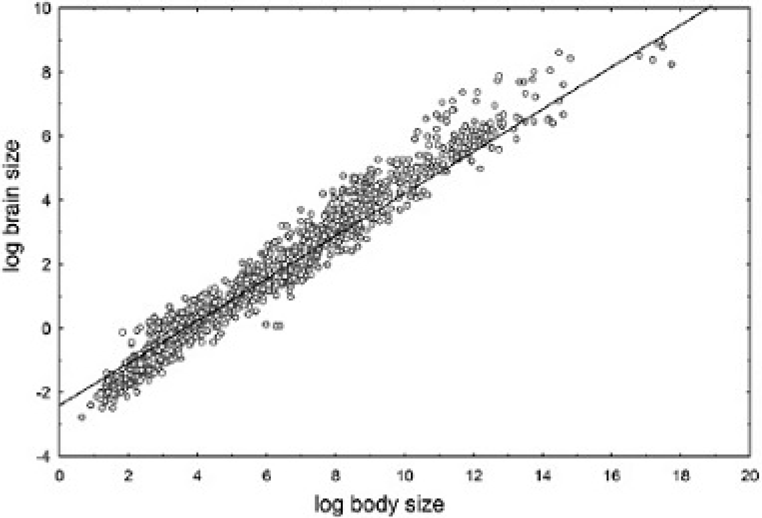


Figure : Plot of the logarithm of the brain mass against the logarithm of body mass in placental mammals.

Inflation of brain size in hominids

One defines the Encephalization Quotient (**EQ**) of a species as the quotient between the actual brain size to the expected brain size (regression line). In this case it has a slope of $\sim 3/4$. It gives an estimate of how much the species departs for the 'expected' Brain Mass/ Body Mass rate, according to the general rule in the group of species chosen.

EQ: Human 7.44, Dolphin 5.31, Chimpanzee 2.49, Mouse 0.50.

If one considers the group of vertebrates, then the human **EQ** is higher than 7.44, and if one considers only primates, it is smaller.

Human EQ is always the highest.

Reference for previous figure: Frynta D, Šimková O, Lišková S, Landová E (2013) Mammalian Collection on Noah's Ark: The Effects of Beauty, Brain and Body Size. PLoS ONE 8(5): e63110. doi:10.1371/journal.pone.0063110.

Inflation of brain size in hominids

The high **EQ** is distinctive of our species, and it has increased progressively in our lineage.

It is correlated to cognitive abilities, which are key in our tremendous success in adapting to many different environments.

The human genome has not changed much since the especies appeared $\sim$200.000 years ago. The appearance of the **Y** chromosome goes back to $\sim$180.000 million years ago. So the encephalization process occurred much after the differentiation of sexes and it is independent of it.

Inflation of brain size in hominids

Differences between males and females are encoded in the (non recombining part of the) **Y** chromosome. They are inherited in a male line.

The encephalization process appears in both, males and females, so it cannot rely on the **Y** chromosome.

Most of the gen pool is shared by the two sexes and presumably, since they are <u>vital</u>, the genes that affect cognitive abilities are passed to all the progeny.

The role of the **Y** chromosome is to enhance the male differentiation through the production of testosterone.
It should NOT play a fundamental role on aspects that are beneficial also for females.

Motivation

Often we see reasonings that seem to assume the premise that males and females evolve in separate lines. Whenever such discussions appear, we should bear in mind that we belong to the same species and that we share our genes.

We would like that this introduction serves to wash out the preconceptions that we may have about biological differences in the capacity of male and female brains.

It is very unlikely that we may prove any of them...

'Age group and sex differences in performance on a computerized neurocognitive battery in children age 8 to 21.' Gur et al. Neuropsychology, **26**(2), Mar 2012, 251-265.

From the Abstract

" ... executive-control, episodic memory, complex cognition, social cognition, and sensorimotor speed domains.

...

We tested a population-based sample of 3,500 genotyped youths ages 8 to 21 years. Results:

...

Sex differences had much smaller effect sizes but were <u>evident</u>, with females outperforming males on attention, word and face memory, reasoning speed, and all social cognition tests and males outperforming females in spatial processing and sensorimotor and motor speed."

Neurosexism?

Of 26 different tests, 11 shown almost no difference among sexes ($< 53\%$)
Biggest differences: on social cognition and spacial processing ($\backsim 60\%$).

Still the authors consider the differences ‘evident’ and in their article they relate it to differences in brain ‘wiring’.
They also speak about ‘behavioural complementarity’.

They affirm that ‘sex differences have been extensively documented in behavioural measures’. But... one may raise some doubts.

The main criticism to the interpretation of these data as biological differences is that sex has a profound impact on the experiences that the individual is exposed to. Given the plasticity of the brain, these experiences may leave neurological traces.

Even the most publicized differences among male and female cognitive abilities are IRRELEVANT and of dubious origin.

No study has ever shown that males are better suited than females for mathematical/abstract reasoning.
In elementary and high school girls and boys perform equally well in scientific subjects.

Common 'wisdom' (foolishness) relates a girl's success in science class to discipline, hard work. For boys it is intelligence.

In some ambients, girls are literally bombarded while they are growing with such type of comments.

Enormous psychological consequences: frustration, feelings of inadequacy, undermined self-confidence, lack of assertiveness.

It is very hard for girls to work against this constant friction. It has an impact on statistics.

Boys also suffer from this discrimination. Sometimes they are pushed against their nature by the demands that the environment puts on them.

These alleged differences are used to justify educative models that segregate boys and girls.

In this war nobody wins. Boys and girls suffer and their development is impaired.

The cost is huge: at the individual level but also at a social level in terms of unused potential.

The lesson to be learnt from our biological background is that

THERE IS HOPE FOR CHANGE

Experiment conducted at Yale University

Departments of Psychology, Psychiatry and the School of Management.

I read about it in the article *Why are there still so few women in science?* by Eileen Pollack. New York Times, October 3, 2013.

Identical (fictitious) résumés were sent to professors of both sexes (127).

Half of the applicants were 'Jennifer' and the other half were 'John'.

Applicant profile: Bachelor degree seeking a position of lab manager. Good qualifications and support letters (not overwhelming).

Professors were asked to rate from 1 to 7 the C.V., considering also if they would mentor her/him and salary range.

Results:

John was rated 0.5 points higher than Jennifer in competence, hirability.

Jennifer was rated 0.5 higher in likebility.

John was offered an average starting salary of $\$30,238$, versus $\$26,508$ for Jennifer.

This was irrespective of the field, seniority of the faculty and also...
... of the gender. Women were as biased as men.

Author's reflection:

"repeated exposure to pervasive cultural stereotypes that portray women as less competent by simultaneously emphasizing their warmth and likability compared to men"

Statistics of post-doc hirings in our field.

Results of previous years									
Year	Candidates	Women	Women %	Taken in our institutes					
				nr.	%	women	%women taken/cand	% men taken/cand	
2014	438	50	11%	54	12%	7	14%	12%	
2013	365	35	10%	40	11%	0	0%	12%	
2012	325	38	12%	35	11%	2	5%	11%	
2011	411	41	10%	25	6%	1	2%	6%	
2010	400	35	9%	34	9%	3	9%	8%	
2009	354	41	12%	24	7%	4	10%	6%	
2008	226	26	12%	25	11%	3	12%	11%	
2007	186	19	10%	20	11%	3	16%	10%	
2006	207	26	13%	33	16%	6	23%	15%	
2005	239	22	9%	18	8%	1	5%	8%	
2004	171	14	8%						
2003	112	29	26%						
2002	96								
2001	51								
2000	83								
1999	83	5	6%						

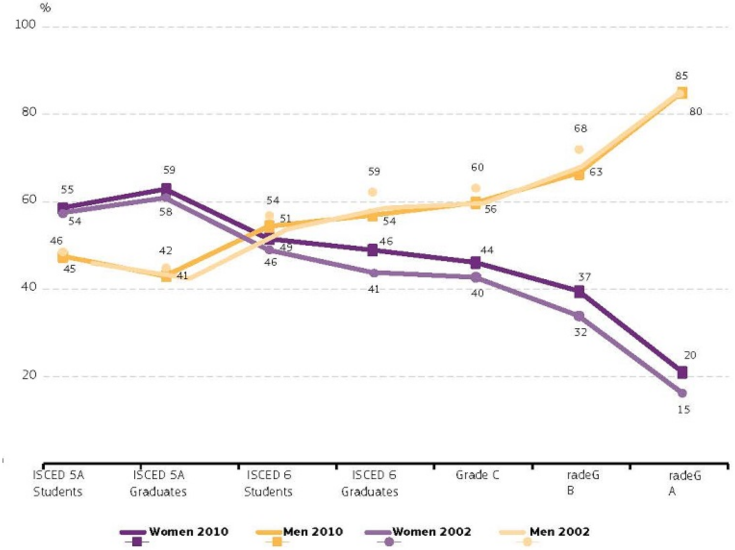
Report by the European Commission: *She figures 2012. Gender in research and innovation.*

Only $\sim 1/3$ of researchers in Europe are women. $< 1/5$ in the private sector.

In 2010, 46% of PhDs were women (women are slowly 'catching up'). Science, mathematics and computing 40%. Engineering 26%.

Women at level A research positions (Full Professor) is 20% (glass ceiling).

Figure 3.1: Proportions of men and women in a typical academic career, students and academic staff, EU-27, 2002–2010



The generation effect is not enough to explain the disparity.

At the current rate, it will take decades to self-correct.

Among the causes of the pronounced disparity of presence of women and men in higher stages of the academic career is the balance between time dedicated to work and to family.

In average, men dedicate less time to family than women.

Persistence of the artificial roles of caregiver and breadwinner.

This necessarily puts many women at a disadvantage with their male colleagues.

Many women accept partial time jobs or settle for a job that is below their qualifications and their ambitions.

If they manage to stay in the career, they face discrimination.

Tight schedules, difficulty to travel and less availability are imposed by the needs of the children.

Also, scientific production may drop for some time.

But this is seen among pairs as lack of commitment.

Many women are left out of decision making circles and they are not considered for relevant positions in the administration.

It is not coincidence that only 10% of rectors in European universities are women and that only 15% of ERC grants go to women.

A similar effect may happen with men. Men that want to dedicate time to children that are growing up have experienced the same type of discrimination.

All these effects, in turn, rarefy even more the ambient and the loop closes.

How could we break it?

Summarizing:

Both, men and women, have the right to play both roles.

Our children are entitled to have the attention of both parents. In a changing world, they could be at a disadvantage if they don't.

Work/life balance should be sought and encouraged in the work place.

We should not punish people for doing the right thing.

Conclusion

The effect of the education, cultural stereotypes and biases acts as a constant friction force in a woman's path to a successful scientific career.

Even a small bias against a group of people, when acting repeatedly, can cause an enormous disparity in a very competitive situation.

Rainer Maria Rilke (1875 to 1926).

Letters to a young poet. Fragment from letter IV (1903/07/16)

"And in the man too there is motherhood, it seems to me, physical and mental; his engendering is also a kind of birthing, and it is birthing when he creates out of his innermost fullness. And perhaps the sexes are more akin than people think, and the great renewal of the world will perhaps consist in one phenomenon: that man and woman, freed from all mistaken feelings and aversions, will seek each other not as opposites but as brother and sister, as neighbors, and will unite as human beings, in order to bear in common, simply, earnestly, and patiently, the heavy sex that has been laid upon them."