

Gender Summit

3rd A-Z guide why gender matters in research and innovation

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A is for **autoimmune diseases**, which affect women much more than men, but not always: in **rheumatoid arthritis** the female:male ratio is 2:1, but in Goodpasture's syndrome it is 1:3.¹ **A** is also for **agriculture**: in developing countries female-owned plots and female-headed households lack access to fertilizers, pesticides, and improved seed varieties². **A** is also for **adverse drug reactions**, which occur twice as often in women than in men³, and in USA alone affect 4.3 million people, annually⁴. **A** is also for **Aviation, Aeronautics** and **Air transport** and the need for more of women engineers in these sectors⁵, and for women leaders, like electronics and aircraft design expert Sue Gray who was promoted in 2013 as UK's **Air Vice-Marshal**, a role that carries responsibility for buying and maintaining all fighters, drones and other **aircrafts**⁶. **A** is also for **ageing** of women and men and about prolonging **active independence** and productive working life: in Europe, in the 60+ **age group** there are 50% more women than men and in the 75+ age group there are 70% more women than men⁷. **A** is also for **agreement** in the scientific community on the need to identify **appropriate animal models** (*non-human primates, rats, mice, rabbits, swine, hamsters, gerbils, quail, and fish*) that can be used to screen for sex-based differences, and be more predictive of the human experience⁸.

B is for **biomarkers** as indicators of (ab)normal **biological processes**, and of clinical efficacy⁹: concentration of biomarkers can differ between women and men, e.g. in metabolic processes¹⁰, and in Asperger's syndrome¹¹, so there is a need to consider sex when comparing their utility for diagnosis and risk stratification¹². Another use of biomarkers is to measure responses of non-human populations to different classes of pollutants, e.g. marine life in coastal regions, including impact on reproduction¹³. **B** is for **bio-banks** (*of DNA, cells, tissue, organs of every kind, blood, urine, saliva, etc.*), which in USA alone hold around half a billion **bio-specimens**¹⁴. Measures are required to ensure females and males are well represented in these collections, and to prevent their misuse, as was the case of the HeLa line cell that was obtained originally from Henrietta Lacks and used in many labs subsequently without awareness or acknowledgement¹⁵. **B** is for the role of user **behavior** (in which biological and socio-economic conditions interact) in the use of public and private transport, e.g. men tend to have much more linear origin to destination behaviours, centred on employment – these income-generating trips are valued more than women's domestic trips and so transport planning prioritises the needs of men¹⁶. **B** is also for **breast cancer screening** using technology developed for land mine detection, which is based on the fact that the dielectric constant in the breast cancer tissue is the same as in the materials used in land mines¹⁷.

C is for the role of **chromosomes** in non-hormonally produced sexual dimorphism, involving, for example, gene silencing of X-chromosome complement¹⁸. **C** is also for **combined risk pathways** where interactions between **genetic control** and behavioural, occupational, environmental, nutritional and other modifiable factors differentiate health effects of women and men¹⁹. **C** is also for gender differences in sensitivities to **chemotherapy**: in women the agent half-life is often longer and is associated with improved survival but also increased toxicity²⁰. **C** is also for **climate change** and need for gender responsive **climate action** concerning temperature-related morbidity and mortality; health effects of extreme weather events; air pollution; water- and food-borne contamination; vector-borne and zoonotic diseases; and exposure to ultraviolet rays, all of which can affect women and men in different ways²¹. **C** is also for **cognitive technologies** and gender stereotyping of social robots²², as well as for **cyber security** and for **cryptography** where greater participation of women is needed²³. **C** is also for **cognitive bias** in decision making of which at least 150 types have been identified so far, and this makes for a strong argument in support of science teams diversity. **C** is for **chicks**, 50 million of which are hatched each day in USA alone, and the poultry industry, which would like an automatic way of separating female eggs/chicks from males²⁴. **C** is also for

Crash test dummies, which are male, so even though women's and men's anatomy differs, e.g. women have less muscle around the neck and upper torso and so experience greater risk of whiplash injury, there are, as yet, no female-specific dummies²⁵. **C** is also for **vehicle crashes** where women are significantly more vulnerable and are 47% more likely to suffer serious injury than men²⁶.

D is for (under-)**diagnosis** in women of illnesses that are commonly associated with men, such as cardiovascular and respiratory diseases²⁷, and autism²⁸ and the under-diagnosis in men of the illnesses that are commonly associated with women, such as breast cancer and osteoporosis²⁹. **D** is also for **diabetes**, the 5th leading cause of death in women in USA³⁰, where paternal diabetes has been linked to lower birth weight suggesting that genetic factors may influence foetal growth and type 2 diabetes³¹. **D** is also for **disasters**, where post-traumatic stress **disorders** have been linked to maladaptive behaviours (alcohol or **drug abuse**, violence) occurring with greater severity among men, which then produce important consequences for women³², and for **disaster-resilience**³³ measures that are equally effective for women and for men. **D** is for cell **death** and **disease**: sex difference in the cell **death program** have been demonstrated in mice suggesting that targeting cell death based on sex may lead to tailored and better treatments for women and men³⁴. **D** is for **drugs withdrawn** from the market in the US, where between 1997-2000, 8 of the 10 prescription drugs removed posed greater health risk for women than for men³⁵. **D** is also for radiation **dosimetry models**, where there is a need for improved bio-**dosimetric techniques** to assist in long-term epidemiologic investigations so that radiation cancer risks for women, men and children can be more accurately calculated³⁶ and the Reference Man can be 'retired'³⁷.

E is for **energy** and the missing women in the governance of **energy sector**; in discussions concerning **energy needs** or **energy supply**; in **evaluation** of site-specific impacts (e.g. population displacement); in **energy end-use** (e.g. domestic) or social development (e.g. better livelihood and poverty reduction); and in **environmental effects** of waste flows and **emissions** as part of **energy production**³⁸. **E** is for the **energy used** in **European countries**, which in transport is greater among men: in Germany and Norway men consume 70-80% more energy than women; in Sweden 100%; and in Greece 350%³⁹. **E** is also for higher **environmental awareness** of women in the spheres of waste, consumption and mobility, and for **exclusion of women** from the **energy economy**⁴⁰. **E** is also for **evidence-based medicine**, which may be fundamentally flawed because there is an on-going failure of research tools to include sex differences as primary variable in study design and analysis⁴¹. **E** is also for **environmental concern** and its intersections with gender: women tend to express a greater level of environmental concern than men but there are significant interactions between gender and various socio-demographic characteristics⁴². **E** is for **education of women**: in **European universities** nearly 60% of graduates are female; **E** is also for increasing female **employment rates**, which **economists** at Goldman Sachs described as a more **effective growth policy** than quantitative easing⁴³.

F is for **food (in)security** that is generally measured not at individual⁴⁴ but at household level (e.g. household income and expenditure), and this can overlook gender disparities in **food production**, in **access to food**⁴⁵, and in the effects of nutrition on the health of women and men⁴⁶. **F** is also for **Functional Magnetic Resonance** used to study/demonstrate differences between the **brains of females** and males, which can reinforce gender stereotypes in the eyes of the public⁴⁷. **F** is also for **fertility** and ecological wellbeing of non-human populations, which can be affected by exposure to toxic chemicals that are then stored in the bodies: often, males and females respond to harmful chemicals in different ways⁴⁸. **F** is for the role of **flowers** as entry points for microbial and **fungal attack** during pollination and the differences in the infection rates between male and **female plants**, knowledge of these differences can help develop ways of promoting pathogen resistance in plants⁴⁹. **F** is also for **forensic identification** of gender by testing for presence and concentrations of creatine kinase (CK) and alanine transaminase (ALT) in serum solutions⁵⁰. **F** is for 57,000 **FoldIT** gamers - 30% of whom are women - who solved a scientific problem of protein

structure that scientists could not solve for over 10 years⁵¹. **F** is for also **fungi** and their sexual reproduction: in *Penicillium chrysogenum*, the genes that regulate sexual ability also control the **amount of penicillin the fungus produces**: more penicillin is produced during sexual reproduction⁵².

G is for **gender-specific medicine**, which examines how normal human biology and physiology, diagnosis and treatment of diseases differ between men and women, e.g. in terms of prevention, clinical signs, therapeutic approach, prognosis, psychological and social impact⁵³. **G** is for genetic underpinnings of complex traits that differ between women and men, such as height, weight and body fat, which may lead to a better understanding of disease mechanisms with a potential relevance to treatment options.⁵⁴ **G** is for **Gibberellins**, plant hormones widely used by commercial **growers**, which stimulate stem elongation, but also control various aspects of seed **germination**, including the loss of dormancy and the mobilisation of endosperm reserves, that can induce feminization of male flowers, e.g. in maize⁵⁵. **G** is also for **gut microbiota** and its influence on physiological responses and contribution to autoimmune diseases: studies on mice show, for example, that adult puberty affects the male microbiota composition, which becomes less diverse than the female microbiota⁵⁶. **G** is for **gender pay gap**: there is no country in the world where women earn more than men⁵⁷ – the gap is now 23%⁵⁸. **G** is also for **human genome** and a variety of **gender issues** across a number of dimensions: the level of attention given to the **nuclear genome** as opposed to the mitochondrial (maternal); the historical exclusion of X chromosome from **Genome Wide Association Studies**⁵⁹.

H is for development of **homeostatic biomarkers** that could be used to monitor relationship between ageing and **healthy longevity** (*defined as correct functioning of immune system*)⁶⁰. **H** is also for **homophily**, the tendency for similar individuals to associate: women and men differ in the tendency to associate with certain types of dissimilar personalities, suggesting that males are able to bridge larger areas of social space in their interpersonal networks, and are more likely to accumulate greater social capital than women as a consequence⁶¹. **H** is also for **human rights** of women to participate at all decision making levels on resolving conflict issues and in peace building, as well as in security and defence policy identified in UNSCRs 1888, 1889 and 1960 resolutions⁶². **H** is for **HIV/AIDS**: in the U.S. 1.1 million people live with HIV, 24% are women; most are infected through **heterosexual sex** - antiretroviral therapy reduced **mother-to-child transmission of HIV** to less than 2%⁶³; but globally, women account for half of all infections and in parts of Africa and the Caribbean, young women, ages 15–24, are up to six times more likely to be **HIV-positive** than young men of the same age⁶⁴. **H** is also for mortality in **heart disease** with more women (15%) than men (11%) admitted to hospital dying of heart attack within 30 days⁶⁵. **H** is also for **human factors** governing driving behavior, driving errors, and accident rates with female drivers exhibiting more driving stress than male drivers, and male drivers exhibiting more risky driving styles than female drivers⁶⁶.

I is for **iatrogenic illness**, the third leading cause of death in the world caused by medical errors, unnecessary surgery, adverse drug reactions or **hospital-acquired infections**: women have 2-fold higher risk of adverse reaction to drugs; are more likely to be hospitalized; and have unnecessary surgical procedure⁶⁷. **I** is also for safety of **implants** such as knee replacements - osteoarthritis occurs 1.7 time more in women than men⁶⁸. Pacemaker implants produce outcomes less favourable for women⁶⁹. Hip replacements have higher failure rates in women due to aseptic loosening⁷⁰. **I** is also for **imaging studies**, e.g. showing gender differences in brain glucose metabolism and metabolic networks⁷¹. **I** is for **infectious epidemics** where sex and gender differences in exposure, transmission, **incidence**, severity and mortality start at **infancy** and continue in some form throughout life⁷². **I** is also for **insulin resistance**, important in the pathogenesis of Type 2 Diabetes, which is higher in men than in women⁷³; this has been linked to a lower risk of coronary heart disease in women of childbearing age explained by their higher insulin sensitivity in the muscles⁷⁴. In animal studies, **maternal insulin sensitivity** has been shown to influence glucose metabolism in the fetus and in the newborn that persists through later life stages⁷⁵. **I** is also for

collective intelligence, which increases with improved gender balance of the group, i.e. neither women nor men are in a significant minority⁷⁶. **I** is also for **innovative** and **inclusive ways** to solve technological problems: among the 12,000 problem solvers studied on www.innocentive.com, which broadcasts problems **industry** cannot solve, “being female was positively and significantly related with being a winning solver”⁷⁷.

J is for **joint arthroplasty**: it has been accepted that there are gender-specific differences in knee and hip anatomy but this has not produced an agreement on if and how these differences should be addressed⁷⁸. Even though women have 29% higher risk of short-term implant failure following total hip arthroplasty⁷⁹, and women account for nearly two-thirds of the approximately 400,000 people in the U.S. who receive knee replacements each year, the role of the differences between the shape of men's and women's knees has not been fully addressed⁸⁰. **J** is also for **judicial thinking** where a feminist perspective can often challenge the established dogma and traditional beliefs underlying the decisions, showing a common disregard for protecting women's rights on an equal basis to men⁸¹. **J** is also for **judicial empathy**: having daughters have been shown to influence **judges' decisions** where females were involved⁸². **J** is also for **journals**, such as *The Lancet*, which was one of the early proponents of an editorial policy requiring that authors include information on gender aspects in their research reports⁸³. **J** is also for **junior scientists** (*graduate students and postdoctoral fellows*), among whom a much greater proportion of women than men worry that a science career will prevent them from having a family: 29% of women but only 7% of men⁸⁴.

K is for **kinesthesia**, which provides humans with an awareness of the position and movement of body parts, whether such movement is self generated or externally imposed, and plays a key role in Virtual Environments to control operator's ability to estimate force magnitude and variations. Gender **kinesthetic asymmetry** has been shown in hand grasp with females have an average of 59.5% of male power grasp force and 51% of male wrist force⁸⁵ – such details can influence the design of gloves used in real and artificial environments, e.g. astronauts⁸⁶. **K** is also for **kinome**, a family of **kinase enzymes** that coordinate complex cellular functions such as cell cycle. For instance, sex-specific **protein kinases** are involved in sex-specific regulatory pathways and sexual development of malaria causing *Plasmodium*, and have been identified as an attractive target for developing new strategies that can prevent pathogen transmission⁸⁷. **K** is also for **knowledge economy** and **knowledge society**, and the potential to change the nature of gender relations by shifting organisational gender structures and occupational hierarchies to encourage women's advantage⁸⁸. **K** is also for **knowledge making in science**, where extensive research evidence shows the presence and influence of a variety of gender biases and gender related errors that have been created through mistaken adoption of male as the norm, or exclusion of females from research design and content⁸⁹. **K** is also for improving researchers' and innovators' **knowledge** of how gender inequalities impact on quality of their own work⁹⁰.

L is for **language use**, where analysis of 14,000 text files from 70 separate studies showed that women used more words related to psychological and social processes whilst men referred more to object properties and impersonal topics, and these effects were consistent across different contexts with a pattern of variation suggesting that gender differences are larger on tasks that place fewer constraints on language use⁹¹. **L** is also for the very **low likelihood** that women life scientists are invited to join scientific boards of for-profit biotechnology companies, or contribute to patents - the **largest gender gap** is found among faculty members at the highest-status institutions⁹². **L** is also for **lateralized brain regions**, which sub-serve different functions such as **language** or **visuo-spatial processing**, and the mistaken hypothesis that individuals may be **left-brain** dominant or **right-brain** dominant: neuroimaging data has not provided clear evidence whether such phenotypic differences in the strength of **left-dominant** or **right-dominant** networks exist⁹³. **L** is for **leadership styles**, which can differ between women and men: the presence of women improves performance and cultures but there must be at least 30% of them so that they are seen first as co-

workers and not as women⁹⁴. **L** is also for the ‘leaky-pipeline’, which captures the fact that fewer women than men advance at each academic career step – resulting in less than 14% of women among the heads of Europe’s universities, and even fewer among the heads of research funding bodies.

M is for **microchimerism** where genetic material and cells are bi-directionally exchanged between the foetus and the mother: male-female microchimerism occurs frequently and is widely distributed in the human male brain⁹⁵, and in female heart⁹⁶. **M** is also for **malleability** of gender stereotypes, i.e. stereotypes are flexible, dynamic structures that change with the passage of time, but automatic stereotypes about men differ in their malleability from those about women^{97 98}. **M** is also for **male morbidity** and **mortality**: men have lower life expectancy than women in most countries around the world, a pattern that is consistent regardless of geography, race and ethnicity. More men die of 12 out of the 15 leading causes of death than women; men have higher morbidity and mortality in coronary heart disease, hypertension, diabetes, and cancer⁹⁹. **M** is for also **maternal milk** and how its composition influences infant behavior, in humans and other **mammals**: researchers found that **milk composition** changes depending on the infant's gender and on whether the conditions for survival are good or bad¹⁰⁰. **M** is also for **breast milk** as a source of progenitor cells¹⁰¹. **M** is for **merit** based recruitment and promotion that prevents the influence of implicit gender stereotypes, gender bias and gatekeeper effects, which impact on promotion decisions¹⁰². **M** is also for new **markets for science knowledge**, which are gender aware, and responsive to the needs of women and men¹⁰³.

N is for **nantechology**, **nanoscience**, **nanoparticles** and **nano-safety** and the question who assesses the risks for women and men, and who ensures that women and men are represented fully in study design in such, fast developing areas: so far the quest for innovation has been firmly gender-blind¹⁰⁴. **N** is also for the **norms** used in research, which have been predominantly *men* and *male* resulting in both “beta bias,” by which women are ignored, and “alpha bias,” by which gender differences are exaggerated¹⁰⁵. **N** is for **nutrition** and the steady weight gain of 0.8lb per year that accumulates over time: between 1971 and 2004, the average dietary intake of calories in the United States increased by 22% among women and by 10% among men¹⁰⁶. **N** is also for gender vulnerabilities in **natural disasters**: in much disaster research, gender is simply a quantitatively measured background characteristic rather than a central analytical element¹⁰⁷. **N** is also for **neglecting females as subjects in life science research**¹⁰⁸, for example, our understanding of pain starts with the male rat model¹⁰⁹; in most anatomy books majority of images and descriptions are of man’s body¹¹⁰.

O is for **outcome measures**, chosen when designing clinical trials, which should be meaningful and reliable, i.e. as subjects, women should not be underrepresented but often they have been¹¹¹. **O** is also for **obesity** where paternal high-fat diet can increase risk of obesity in the baby¹¹². **O** is also for **oxygen-starved oceans** due to hypoxia, which affects marine development and reproduction and is an important stressor, possibly of even greater significance than chemical pollutants¹¹³. **O** is also for ‘**omics**’ data (*genomic, metabolomic, proteomic, phenomic*) and the integration of the sex-gender aspects when establishing validity, utility and cost-effectiveness of these data in promoting health and shaping disease prevention programmes¹¹⁴. **O** is also for **open innovation** paradigm, which promotes concepts of “openness”, “collaboration”, “creativity” and “intuition” that reflect feminine discursive connotations, in reality open innovation is governed by masculine norms and models of organising¹¹⁵. **O** is also for access to research **grant opportunities**: for instance, in the infectious diseases field consistent differences exist in funding received by men and women PIs: women have fewer funded studies and receive less funding in absolute and in relative terms; the median funding awarded to women is lower across most infectious disease areas,

by funder, and type of science¹¹⁶. **O** is for the **organisational structures**, practices and cultures that influence how **people are organised** and who decides how knowledge is produced and applied¹¹⁷; what is prioritised, how resources are allocated, who makes the decisions, how much collaboration there is¹¹⁸.

P is for **pharmacogenetics, pharmacogenomics, personalisation of medicine** and **personal omics profiling** but “although there is a growing interest in individualising medicine, we still lack high-quality data on the **largest group of patients**, namely the women”¹¹⁹. **P** is for **prognostic markers** such as the **prostate-specific antigen (PSA)**, which is not cancer-specific but is routinely used in cancer screening¹²⁰. **P** is also for **poverty reduction programmes**: poverty affects women particularly badly¹²¹. **P** is also for **pollutants** emitted by traditional cooking stoves used in poor households: “kitchen smoke” kills 2 million people (mainly women and children) in the world every year¹²². **P** is also for **phenotypic variability**, where human intra-sex variability is significantly higher in males, and consequently constitutes a fundamental sex difference¹²³. In species with heterogametic males (e.g. humans), male variability in body size is significantly larger than in females, whereas the opposite can be shown for species with heterogametic females (e.g. birds)¹²⁴. **P** is also for **programmed cell death** and the prospect that it is potentially controllable: males and females are prone to different types of cell death and this may explain how sex contributes to the frequency and severity of diseases such as *lupus glomerulonephritis*. Understanding the **molecular pathways** regulating tissue damage in males vs. females will lead to better treatments¹²⁵. **P** is for **low participation** of women in **promoting innovation**¹²⁶; and in production of **patents**¹²⁷; or **products** derived from scientific knowledge¹²⁸. Among the submissions to the **European Patent Office**, only 8% come from women¹²⁹. A 2005 Eurobarometer survey claimed that women are “anti-innovation” and “reluctant” to accept innovation¹³⁰. However, research shows that female researchers in universities can produce patents at the same rate as their male colleagues when encouraged to do so¹³¹. **P** is also for **plant omics** and development of sex-linked molecular markers for determination of sex in plant species, where frequently it is difficult to diagnose **plant sex** before flowering, an issue of great importance in agriculture¹³².

Q is for **quality standards** in professional training on gender issues of people responsible for gender mainstreaming¹³³. **Q** is also for **quantification of environmental exposure** of females and males in epidemiology studies: for example, although a significant number of epidemiological studies on the neurodevelopmental effects of exposure to metal pollutants has been published in the last twenty years, not many of them have considered the possible gender-specific effects¹³⁴. **Q** is also for **quotas for women** and the positive Nordic experience in the area of business¹³⁵. **Q** is also for, a possibly less controversial concept, of **quantitative agreements**, recommended by the head of the German National Academy of Science and Engineering, to achieve greater number of women on executive and supervisory board level, nomination committees, evaluation committees, among peer reviewers, on advisory boards, in discussion forums, and on speaker lists¹³⁶.

R is for **recombination and diversity** in crop plants: a key gene influences genetic recombination during sexual reproduction in wild plant populations: adding extra copies of this gene resulted in a massive boost to recombination and diversity in plant offspring¹³⁷. **R** is also for **regenerative medicine** and the potential of stem cells to **restore** and **rejuvenate** muscle tissue in heart failure¹³⁸ - almost 5 million Americans are living with heart failure and more than half a million new cases are diagnosed annually, with 50,000 people dying each year while awaiting a heart transplant¹³⁹. **R** is for **Radiobiology** and **Radioecology** and the **risks** for women and men: according to NASA, the added risk of a male developing cancer on a 1000-day Mars mission lies somewhere between 1% and 19%; the odds are worse for women, because of breasts and ovaries, the risk to female astronauts is nearly double the risk to males¹⁴⁰. **R** is for **response to drugs**: when the FDA evaluated studies submitted to the agency between 1977 and 1995, they found that over the 20-year period, only 26 studies had data addressing sex differences in drug absorption. Among the 47 datasets for sex differences, none had more than 20 individuals of each sex, most had no more than 10 men or

women. These sample sizes make assessment of sex differences in bioavailability severely limited¹⁴¹. **R** is for **risk awareness** and attitudes to **risk taking** that can differ between women and men, in particular attitudes to **cognitive risk**¹⁴². Observations of how young **female and male researchers** deal with experiments when presented with **unexpected results** show different **reasoning styles**, with women wanting to dig more deeply into the reasons behind and men looking for a different method¹⁴³.

S is for **statins'** ability to decrease cardiovascular events and mortality: a major meta-analysis study recommended that **statin therapy** should be used in appropriate patients where risk is considerable without regard to sex¹⁴⁴. **S** is for dependence on the use of inappropriate **socio-economic units**, such as the household, which can overlook the effects of the **subordination of women**, e.g. women's exclusion from decisions involving family income and property, and their lack of access to and control of household resources¹⁴⁵. **S** is also for **soil threats** and the need for progressive **soil management** measures that consider gender dimension in **soil use** and explore how **soil dynamics** are shaped by historical gendered patterns of **cropping systems** and agricultural inputs, as well as the roles that women and men play in **sustainable** soil management and food **security**¹⁴⁶. **S** is also for **stroke**, which affects 15 million people worldwide each year, and is the leading cause of disability in the United States: the epidemiology of **ischemic stroke** is **sexually dimorphic** in that ischemic events occur with greater frequency in men vs. women regardless of country-of-origin and ethnic culture, demonstrating that innate differences in **stroke risk** exist between the sexes that are independent of hormone exposure¹⁴⁷. **S** is for **sex pheromones**, and their uses in limiting insecticide use to allow proliferation of the pest's natural enemies as part of integrated pest management effort, which, for example, resulted in a 70% reduction of pesticide use in eggplant production in Bangladesh¹⁴⁸. **S** is for **stereotypes** that define gender roles and our attitudes to women and men, which valorise the male over the female in most cultures, including academic and research¹⁴⁹. **S** is also for **stem cell research** where cells taken from female mouse muscle tissue have been shown to have stronger regenerative properties than cells taken from a male mouse tissue, regardless of the sex of the host¹⁵⁰. **S** is also for **sepsis** and **septic complications** where females display greater protection than males¹⁵¹.

T is for **transport proteins**, which play a critical role in **transporting drugs** into and out of all cells, and are consequently involved in hepatobiliary and urinary excretion, and influence **tissue distribution** and elimination pathways, as well as efficacy and **toxicity of drugs** where sex in particular determines what happens¹⁵². **T** is for **Twitter** and the gender differences in the use of language between 'female' and 'male' clusters¹⁵³. **T** is for the **Trivers-Willard** hypothesis, which states that natural selection favours parental investment in daughters when times are hard and in sons when times are easy¹⁵⁴. **T** is also for **Turkers**, a crowdsourcing marketplace platform where young, well-educated women have been participating in greater numbers than men (63%, 37%) in the USA, but reversely so in India (36%, 64%)¹⁵⁵. **T** is also for **transport**, which is demand driven, and so far has assumed a neutral stance regarding different needs of women and men: women are more concerned with safety and personal security, but have less access to transport, and tend to have multiple purposes than men when using transport¹⁵⁶. **T** is also for **tactile sensitivity** where measurement of sensitivity to pressure showed women to be more sensitive than men, with face, trunk and fingers areas being more sensitive than other part of the body¹⁵⁷. **T** is for **taste preference** and **transduction** where evidence for sex differences has been shown in sweet, salt, sour, and bitter tastes, but not in umami and fat tastes¹⁵⁸. **T** is also for **transplantation** and **transplants** and gender issues that affect outcomes at many levels beyond immunologic concerns¹⁵⁹: many diseases leading to transplantation are predominantly expressed in one gender; and organ donation patterns have consistently been defined by a greater **tendency of women to be live donors**¹⁶⁰. **T** is also for **toxicology**: our understanding of **toxic effects**¹⁶¹ is based on male studies but **toxicokinetic sex differences** involve metabolism, lifestyle, psychosocial, and hormonal factors, all of which can modify the kinetics and responsiveness¹⁶².

U is for **urban planning** and gender differences in the use of public spaces - women have been excluded from **urban planning negotiations**¹⁶³. **U** is also for sustainable **urban mobility** where within any given **urban setting** women have inferior access to both private and public means of transport while at the same time they assume a higher share of household-related travel burden, making more trips associated with reproductive and caretaking responsibilities¹⁶⁴. In developed countries, designs of **urban spaces** take into account masculine necessities and pattern of mobility and overlook women's different needs and experiences¹⁶⁵. **U** is also for **user driven innovation** where better use of women's talents and skills can improve success by enhancing: i) access to well-educated employees; ii) decisions, how teams work, problem-solving styles; iii) the role of gender as a driver of creativity and innovation; iv) understanding of user-related needs; v) scope of the design by challenging gendered stereotypes; vi) organisational image¹⁶⁶. **U** is also for **use of social media** and how gender differences in media use affect women's political participation¹⁶⁷.

V is for **validation of risk factors** for diseases and biomarkers¹⁶⁸ and **validation of medical devices** because these products can elicit different responses in women compared to men and are attributable to intrinsic factors (*e.g., genetics, hormones, body size, sex-specific physiology*), extrinsic factors (*e.g. diet, sociocultural issues, environment*) or interactions between these factors; for example, there may be medical conditions that are unique to a certain sex, ethnic or racial group, which should be considered in study recruitment and in reporting of results: covariates associated with female sex (*e.g., size, age, comorbidities, past pregnancies*) may be responsible for certain differences in safety, effectiveness, or design attributes such as failure mode¹⁶⁹. **V** is for **valorisation of diagnostic innovation** in medical, environmental and agricultural sectors through sex-gender differences¹⁷⁰. **V** is also for **vaccines**: women's bodies mount stronger antibody response to the seasonal **flu vaccine** than men's, suggesting reduction in the dosage for women; this could make more vaccine available, for example, to **vulnerable populations** in poor countries; what's more, pregnant women have strikingly different immune responses than women who aren't pregnant¹⁷¹. **V** is also for **vascular healing** process: the greater incidence of cardiovascular disease (CVD) in men and postmenopausal women compared with premenopausal women implies a **vasoprotective phenotype** of females, which may be influenced by sex hormones, particularly oestrogen, which have modulatory effects on the endothelium and circulating cells implicated in **vascular inflammation** and in the development¹⁷².

W is for **Warfarin** use in controlling *Atrial Fibrillation* condition: in the UK, it is estimated that 355,000 AF patients are at high risk of stroke and that 47% are on Warfarin, with males preferentially treated with this drug when evidence clearly identifies females to be at higher risk of thromboembolic events¹⁷³. **W** is for **water** where currently, **women in sub-Saharan Africa** spend an average of about 200 million hours per day **collecting water**, or 40 billion hours per year¹⁷⁴. **W** is for **safe water** innovation that was produced in Sweden, which uses solar energy to purify **contaminated water**: after a few hours in the sun the water is free from the pathogens that cause diseases such as dysentery, salmonella and cholera¹⁷⁵. **W** is also for **water management**: there are no women in national water boards governing the management and distribution of water¹⁷⁶. **W** is for **waste** generated by the oil industry, such as gas flaring, spills that contaminate water, fish and people, females and males¹⁷⁷. **W** is for **women in the workforce** and in the **workplace**: women do more **part-time work** but these jobs are not integrated into the **wider career development** opportunities within the workplaces or within organisations, and the jobs offer only a narrow range of often fairly repetitive tasks¹⁷⁸. **W** is also for **well-being**, defined as 'positive psychology', which is expressed in terms of: human 'flourishing'; optimal functioning; thriving; and the prevention of illness, all of which contribute to people being happy; working harder; identifying problems faster; taking less time off. On average, the level of wellbeing is significantly higher for men than for women¹⁷⁹. **W** is also for **W chromosome** and its role in avian sexual determination, which is at least in part cell autonomous and this suggests control in terms of purely intrinsic genetic factors, independent of any extrinsic signalling, whereas the long-held dogma is that vertebrate sexual differentiation is non-cell autonomous, that is, it

also involves some degree of extrinsic signalling, e.g. sex hormones secreted from the gonads¹⁸⁰. **W** is also for **Womenomics**, a term coined by the Goldman Sachs in recognition of women's growing participation in labour markets¹⁸¹, and their control, according to the 2009 estimate by the **World Bank Group**, of \$28 trillion consumer budget, annually.

Y is for **Y chromosome**, which in humans is responsible for important biological roles such as sex determination and male fertility, and which recently has been associated with higher risk of coronary artery disease in men of European ancestry, possibly through interactions in immunity and inflammation¹⁸². **Y** is also for the **Human Y Chromosome Proteome Project**¹⁸³. **Y** is for **years of education**: in OECD countries, women born between 1975-1979 had more years of education than men except for Austria, Germany, Switzerland, and Turkey, and women have been in majority among university graduates except for Germany, Switzerland, and Turkey¹⁸⁴. This reversal of the *gender education gap* has occurred in almost all developed countries and in many developing countries as well; such reversals occurred also among cohorts born over 60 years ago in several countries¹⁸⁵. **Y** is also for **yolk androgen** in eggs, the presence and the level of which has ecological and evolutionary significance, understanding of which will help uncover maternal effects in birds¹⁸⁶. **Y** is for **yougurt commercials**, which in the U.S. have been embedded with messages about gender, consumption, and love¹⁸⁷.

X is for **X chromosome** and the effects of random **X chromosome inactivation** in XX cells¹⁸⁸, as well as **X chromosome dosage compensation**¹⁸⁹, which makes XX cells different to XY cells, and means that genetic biology should be considered for any disease or phenotype that occurs in one sex more than the other¹⁹⁰, because the disease mechanism may be influenced directly by an **X-linked gene**¹⁹¹ or indirectly through the consequences of X inactivation: in some cases the dynamic interactions between cells in mosaic females lead to female-specific disease manifestations¹⁹². **X** is for **Xenoestrogens**, synthetic or natural chemicals that mimic the effects of endogenous oestrogen, which mediate critical points in carcinogenesis by binding to oestrogen receptors. They are involved in cancer types related with environmental exposure. Their effects are important because childhood cancer incidence increases 1% a year all over Europe, and in the adult population a rising trend is reported for *soft tissue sarcoma, brain tumours, germ-cell tumours, lymphomas, renal cancers, leukemias, breast cancer, and lung cancer* in women¹⁹³. **X** is also for **xenografts**, tissue from an individual of one species transplanted into or grafted onto an organism of another species. Xenografts obtained by grafting tumor fragments into immuno-compromised mice have been used to develop novel therapies that are urgently needed to improve patient survival and prognosis in pancreatic adenocarcinoma, which remains one of the most lethal cancers, and is more common in men than in women¹⁹⁴.

Z is for **Zoonotic diseases**, contagious diseases spread between animals and humans caused by *bacteria, viruses, parasites, and fungi* carried by animals and insects, and their effect on women, who, in developing world, are predominantly responsible for the care of domestic animals¹⁹⁵. Currently, one new disease is emerging every four months, 75% of these originate in animals¹⁹⁶. Epidemic-prone infections, both well-established diseases such as *meningitis, cholera and dengue fever*, as well as newly emerging diseases such as *Ebola haemorrhagic fever and SARS*, involve important sex and gender differences¹⁹⁷. World's domestic livestock population has been estimated to be around 24 billion, and in the least developed countries zoonotic diseases account for up 25% of the infectious disease burden¹⁹⁸. *Ascaris Lumbricoides* (tape worm) for instance, infects 1.4 Billion people in 150 countries, and is an important cause of malnutrition, in particular in children, with male children infected more frequently owing to a greater propensity to eat soil¹⁹⁹. **Z** is for **Zoonotic pathogens** such as *Campylobacter, Cryptosporidiosis, Hepatitis E virus, and Escherichia coli*, which have important public health consequences, being among the most important causes of food-borne disease, which can be potentially fatal for pregnant women²⁰⁰. **Z** is also for **zygote** and the early

stage embryonic growth, which shows different rates of growth for male and female human embryos, and this questions the belief that all sex differences in later-life are due to gonadal hormones²⁰¹.

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