THE ROLE OF SEX IN HUMAN EVOLUTION *

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The literary star of Dr. C. Louis Leipoldt is in the ascendant and, as a poet, his name will always be remembered. What might be forgotten is that this great lover and pioneer of Afrikaans had a powerful and a fluent English pen, which he wielded for a lifetime in the cause of Medicine and for the advancement of the Medical Association of South Africa. It is fitting, therefore, that the Cape Western Branch of that Association should have decided to commemorate the medical activities of this great literary and wide-reaching mind. That the memorial should take the form of a medical lecture is also appropriate and would have pleased Leipoldt, because he wished always to be regarded as a practising doctor, as well as being a writer on many subjects and the editor of a medical journal. He knew also full well that memorials in words can be as lasting as in stone.

That it should have fallen to me to be singled out from his contemporaries and friends to pay the first tribute in this form is a very great honour, and in expressing my grateful thanks for this compliment I trust that the subject I have chosen befits the occasion.

In publishing an earlier paper[1] of mine, Dr. Leipoldt wrote in an editorial 'Anthropology and Medicine are correlated sciences, and their interests overlap'. They certainly overlap in any discussion of the problem of sex in relationship to human evolution, because sex in all its manifold aspects obtrudes itself in medicine,

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and a consideration of sexual relationships and sex morphology is basic in anthropology. The evolutionary principle has also now crept into several branches of medicine, such as bacteriology and virology, and it is fundamental to biology and anthropology.

THE SCOPE OF THE SEX PROBLEM

The subject of sex is a protean one, and the books and articles that have been written on it are legion. It has a social side, and the rules and regulations governing sexual behaviour that have been evolved by different societies of mankind form the framework of their whole social structure. In individuals, sex is a many-sided phenomenon. The normal bisexual arrangement is manifested by the different anatomical structure of the male and female sex organs. This difference goes very deep, extending to the chromosomes and genes not only of the sex cells but of all the cells in the bodies of those of different sex. As a result of the presence of these curious little structures in the cellular make-up of the body the constitution of males and females is quite different.

Apart from the obvious physiological difference between the sexes in reproduction, males and females have a different glandular metabolism, and this internal chemical difference is reflected in a great number of different ways. Grouping the anatomical and physiological characteristics of the male as manifestations of 'masculinism' and those of the female as 'feminism', it is the object of this address to show how, by means of the sex mechanism, there has been an interplay between masculinism and feminism as part of the evolutionary machinery. In the animal world fierce masculinism has undoubtedly played the dominant role, whereas it would appear that in human evolution the refinements of feminism have been a major factor.

As deep-rooted as anything in biology is the sexual instinct, and a characteristic feature of different animals is their sexual behaviour. Man is no exception and in his case the psychological aspect of sex is probably the most important one.

Sex is without a doubt a great mental driving force, a sort of biological hunger in both males and females, and in all human societies social sanctions and taboos of one kind or another have been set up to regulate sex behaviour. Without the stimulating influence of sex the human mind could not have blossomed out in art, music and literature the way it has done. Can there be any doubt about the importance of sex as a creative factor in both social and organic evolution?

THE EVOLUTION OF SEX

For the beginnings of sexuality in animals we must look to the behaviour of unicellular organisms, such as some of the protozoa. These propagate themselves for the most part asexually, that is to say by a simple division of one cell into two new ones. Under appropriate conditions, however, two of the cells may come together and form one cell with a fusion of their nuclei and a doubling of the number of the chromosomes. Ultimately these 'fertilized' cells divide into two, each of the 'daughter' cells taking half of the combined chromosomes. In this way there arises a new rejuvenated generation of cells which continue to divide asexually. This simple process is worth emphasizing, because it foreshadows what happens in the higher animals, where male and female sex cells unite and form the body cells, which divide asexually as they grow to form the body.

In the next stage of evolution we get multicellular creatures with a differentiation of the structure and function of the cells to form the different tissues of the body. Thus there are skin, nerve, muscle, glandular and sex cells.

Gradually as we ascend the animal scale the sex cells become differentiated into male and female forms. The male sex cells develop into small and usually highly motile spermatozoa, whilst the female germ cells retain their cellular form and usually enlarge to form the ova or eggs.

In such forms as snails and slugs every individual has a single sex gland which produces both eggs and spermatozoa. Worms on the other hand have separate sex glands, that is to say testes and ovaries. They and many other invertebrates are therefore called hermaphrodites. Self-fertilization, which is so common in flowers, is, however, rare, and in these lower forms there is already a copulatory mechanism. This ensures that in fertilization there is a union of the sex cells of two different individuals. It should be noted, however, that in these hermaphrodites there is no detectable difference in the chromosomes of the male and female sex cells. Their male and female parts are simply different organs of the same body.

In all the higher animals there is a separation of the sexes into males and females. This gives each species an opportunity for a division of labour in the interest of the species, for the male to be more active and to give protection, and for the female to be more passive and produce the eggs or the young. In some species the sexes look very different, whereas in others the males and females are outwardly hardly distinguishable. Examples of the former extreme sexual dimorphism are the peacock and the peahen, whereas the cock and hen pigeon are very much alike. Amongst the primates the skull of the male gorilla is very different from that of the female, so much so that the two sexes look as if they represented different species. This extreme differentiation gets less and less as we ascend from Ape to Man, until we come to the Bushman, where the skulls of males and females are indistinguishable.

It would seem then that just as the crossing of two interfertile species may give rise to a new species, so the 'crossing' of the two different sexes, that is to say of masculinism and feminism, probably played a very important part in human evolution.

SEX AS AN EVOLUTIONARY FACTOR

Darwin devoted much of his time and many of his writings to a study of the influence of sex on the evolutionary process. The key to the riddle of sex, however, was still denied to his generation, and he had only his own clear vision of what the human pedigree has turned out to be. Of particular importance to Darwin was the prodigality with which the germ cells, particularly the male ones, are produced, and the multiplicity of generations, because these were the means by which Nature increased her chances of producing those variations, which accumulate and lead to the formation of new species.

He also recognized the different environmental conditions to which males and females are subjected in the wild state. There the males have to develop special strength and ferocity, and have often to be literally armed to the teeth to catch their prey and cope with enemies from without. At the same time they have to be relatively better armed than their rivals within the species in order to win a mate. It is clearly for them a matter of 'the survival of the fittest'.

The female on the other hand has the protection of the male, and is practically in the same position as a domesticated animal. As a consequence the female is able to show a refinement of structure, a docility of temperament, and those maternal instincts which are so necessary for the rearing of her family.

But it is easy to see that in the wild state any transference of feminism to the anatomy or temperament of the male would lead to his elimination in the struggle for existence. On the other hand the position would be very different if selection value were given to feminism in the male, and that is very probably the means which prehistoric Man used to accomplish that greatest of biological achievements, namely the domestication of the various breeds of birds and animals. Other important factors, however, come into this process. For example, that most intelligent of creatures, the Indian elephant, is captured in a wild state, and it is tamed and trained by being brought into close contact with an elephant that has already been domesticated. This suggests that wild animals are not necessarily wild by instinct, but that they are educated in 'wildness', and can be just as readily educated in 'tameness' by example.

There is a lesson in this which the human race can take to heart, because there is nothing to justify the belief than Man, for all the anatomical feminism which he appears to have, has shaken off much of his psychological masculinism. His civilized behaviour and general culture still depend largely on education by example, and that is particularly true in matters of sex.

There is a great deal to be said for the idea that it was by a process analagous to the domestication of animals that Man has, so to speak, domesticated himself. Having made the great discovery of the advantage of using weapons instead of teeth, he could afford to sacrifice his anatomical armaments, and replace his masculinism with the refinements of feminism.

Sexual Selection

Darwin credited the females of certain species with what amounts to conscious sexual discrimination, attributing the beauty of the sexual serenades of male birds, and the exquisite colouring of

the peacock's tail to the good artistic taste of generations of females.

There is no doubt that conscious sexual selection on the part of the human female, who is free to choose brain rather than or as well as brawn, has had a powerful influence on human evolution. It has not yet, however, been sufficiently stressed how the invention of weapons, besides benefiting Man, led at the same time to the anatomical and psychological emancipation of women. Now for the first time in evolution female anatomy acquired the same survival value as that of the male in the struggle for existence. It was as easy for the human female to strike a lethal blow with a club or dagger as it was for the male. She could go further, and by choosing a suitable partner she could transmit the refinements of her anatomy and temperament to her sons without prejudice to their survival. That this actually happened is suggested by the frequency with which degrees of feminism appear in the male at different stages of the human fossil pedigree.

Feminism or Gynomorphism in Human Evolution

The advance from Ape to Man has been characterized, on the one hand, by a gradual reduction of the size of the teeth, and, on the other, by a great enlargement of the brain. The usual explanation of this is that teeth, like all other structures tend to vary or mutate in size, and that by an economy of Nature smaller teeth were developed, because with the invention of weapons, they had as good survival value as bigger teeth used to have. But the appearance of smaller teeth in a subsequent generation need not be regarded as altogether a matter of chance. It can be explained equally well by regarding it as an example of feminism that is to say of the smaller female teeth of one generation appearing in the male of a second generation.

That this example of the alternation of feminism with masculinism is not confined to individuals is shown by the contrasting features of the two 'living fossil' races, namely, the South African and the Australian Bushman. As already mentioned, the South African Bushman skull is practically identical with that of the South African Bushwoman, and their teeth are the smallest in the human family. The Bushman could afford to be feminized anatomically, because he had the bow and poisoned arrow. On the other hand the Australian Bushwoman's skull is very similar to the coarse Neanderthaloid skull of the Australian Bushman, and their teeth are the largest still existing in the human family. The position therefore is that at the moment there is in actual existence one primitive race which has become completely feminized and another which has become completely masculinized.

An analagous feministic argument may be used to explain the gradual increase in size of the human brain, because the female brain, relative to the weight of her body, is always 10% heavier than that of the male. Moreover, the prolonged infantilism of the human child, which accounts for the great growth of the human brain relative to that of the ape, is feministic to the extent that it has been brought about by a gradual prolongation of the time which the human female takes to reach sexual maturity.

For an explanation of the evolutionary machinery by which male and female features have on the one hand been entrenched, and on the other bandied about from sex to sex, it is necessary now to give some consideration to the meaning and mechanism of Sex itself.

THE MEANING AND MECHANISM OF SEX

Until the beginning of this century little was known about maleness or femaleness beyond their procreative purpose. There was the strange unflattering story of the creation of Eve from one of Adam's ribs, and complete darkness as to the origin of sex in other living creatures. Less well known, but much more plausible, because it can happen in butterflies, etc., was Plato's romantic myth that human beings were at one time male on one side and female on the other. Tradition had it that the gods became displeased with this eminently fair arrangement, and decided to sunder them apart as man and woman, who forever afterwards have been striving to regain their lost wholeness. Equally speculative were the so-called scientific theories about the meaning of sex that were current until little over fifty years ago.

The clearing up of the mystery of sex had to await the rediscovery in 1900 of the basic laws of inheritance, which had been worked out by Gregor Mendel, until then a forgotten contemporary of Darwin. This discovery has proved to be one of the greatest milestones in the history of biology, and it constitutes the foundation of that new branch of science called genetics. The name derives from the fact that countless observations and experiments on the inheritance of different features in plants and animals have shown that this is controlled by ultra-minute genes situated on the chromosomes of the cell nuclei of different species.

One of the most important outcomes of this work has been the discovery that the inheritance of sex itself, and of the so-called sex-linked characters, is determined by genes, and conforms to Mendelian law. An elementary knowledge of the genetic mechanism of sex and of the early stages of development of the sex organs is therefore necessary for a proper understanding of the important part which sex seems to have played in evolution.

Chromosomes and Genes

All animals are built up of microscopical units called cells, and within the darker staining nucleus of each cell there are minute paired bodies called chromosomes, linked to which there are exceedingly minute genes. The number of chromosomes in each cell varies from species to species; in man it is 48, that is to say 24 pairs. During cell division the chromosomes look like tiny hieroglyphics or shorthand symbols, which indeed they are, since they and the genes they carry determine the features of the body such as the colour of the skin, hair and eyes, and also sex. The easiest pair to decipher is the sex pair, which are alike in the human female and are usually referred to as the XX pair, whereas in the male they differ and constitute the XY pair.

As the female germ cell or ovum matures it discards one-half of its chromosomes, including one of the Xs. On the other hand the mature male germ cell divides into two, each half containing half the chromosomes, and each becomes a motile spermatozoon, one taking the X- and the other the Y-chromosome. The chances whether an X- or a Y-spermatozoon fertilizes, that is to say gets inside the X-ovum, are equal. If an XX combination results, the sex of the child is female, whereas an XY combination results in a male.

Besides arranging for sex this machinery has also a provision for the crossing-over of genes from one member of each pair of chromosomes to the other member of that pair. In this way the genetic patterns of the male and female germ cells are shuffled like 4 packs of cards. As a result, the parental characters represented by the genes are distributed more or less at random, feature by feature, to the offspring. On the whole the 'deal' is a balanced 50-50 one, so that the general features of a race or stock are maintained unchanged. What seems hitherto to have been generally overlooked, however, from the evolutionary point of view is that there is at least one direction in which the deal is manipulated to the extent that it is known to which party certain genes must go.

Thus it is now known that genes which are attached to an X-chromosome must go the same way as this X-chromosome goes in the sex mechanism just described. For example a son gets his one and only X-chromosome from his mother, and he passes this same X-chromosome for certain to all his daughters. A daughter on the other hand gets one X-chromosome from her father and another from her mother, so that it is a matter of chance which of these Xs passes to her offspring. Medical men are familiar with this phenomenon in the inheritance of haemophilia and colour blindness. These peculiarities are sex-linked to the extent that the genes which are responsible for them are attached to an X-chromosome, and they are transmitted in conformity with the behaviour of the X-chromosome in sex determination.

However, the term 'sex-linked' which is applied to these defects is misleading, because they are only X-linked, and they can appear in both males and females. The only difference is in the proportions in which they crop up in the two sexes. The greater frequency of haemophilia in the male is due to the fact that when the gene for this condition is present on his X-chromosome, he inevitably manifests the condition, because there is no normal gene on his Y-chromosome to counteract it. On the other hand, when the gene for haemophilia is present on only one of the X-chromosomes of a female, as is usually the case, the normal gene on her other X-chromosome seems to counteract its morbid influence, so that she is not a 'bleeder'; she is what is called a 'carrier', because there is an even chance that she will transmit this morbid gene to her offspring. It is only in the rare event of there being a gene for haemophilia on both her X-chromosomes that a female becomes an actual bleeder.

This interesting type of inheritance has been stressed because it is not always morbid. Some of the most valuable genes in the body are in fact attached to or controlled by the X-chromosome. Animal breeders, for example, are well aware that a cow with a good pedigree and a good milking record is practically certain to transfer these valuable genetic qualities *via* her X-chromosome to the genetic make-up of her male offspring; hence the seemingly fantastic prices that are sometimes paid for pedigree bulls. The farmer knows that by using a good bull and exercising careful selection and a degree of inbreeding he can improve the quality of a herd in a very short time. States also know that with the practice of artificial insemination the breed of the whole cattle population of a country can be very quickly improved.

Mention must be made of another possible imbalance in connection with the distribution of the genes. It has been pointed out already that as the ovum prepares for fertilization it discards one-half of its chromosomes, including one of the Xs. This may be done at random, but it is quite possible that some subtle 'chemical selection' is exercised and that the ovum retains those genes which are or have become best adjusted to the chemical constitution of the maternal body. It will be shown later that the maternal hormones have a powerful influence over the genes of the embryo and there seems no reason why they should not alter the genes in the same way as radiation does. This is in conformity with the Lamarckian theory of evolution, a doctrine which was supported by Darwin and is still advocated today. It postulates that the individual in some way determines what is likely to be 'of use or of no use' to the species.

A somewhat analagous argument has been used in connection with the male germ cells to explain runs of males and runs of females in certain families. There it has been assumed that a greater adaptability and vitality of the Y-containing spermatoza could account for a run of males, whilst a different kind of 'chemical selection' favouring the X-containing spermatozoa could be the explanation of a run of females.

It has been necessary to give this somewhat lengthy discussion to the imbalance in the sex mechanism, because just as we have seen how it can provide the machinery for creating new breeds of animals, so it is more than likely that it was by this same sex mechanism that the human race has been stepped up.

The Glandular Influence on Sex

The discussion of the sex mechanism has been confined so far to the behaviour of the sex or germ cells in relationship to fertilization and the determination of sex. Fundamental and decisive as this is, it is merely the beginning of the complicated process which has still to go on in order to differentiate the male and female body. Some consideration has therefore to be given to the way in which the single-cell ovum becomes the multicellular human body.

Immediately after fertilization the ovum divides into 2, 4, 8 etc. cells and forms the multicellular embryo. One of the earliest activities of these cells is to form structures which protect the embryo and attach it to the mother's womb. The chief of these structures is the placenta, whose function terminates at birth when it is destroyed as the 'afterbirth'.

The other cells form 3 layers from which the bones, muscles, nerves, bloodvessels, glands etc. of the body are formed. The most important of these from the point of view of sex and of survival are the sex organs, and in particular the sex glands—the testes and the ovaries. Other glands such as the pituitary, thyroid, and the suprarenals are also formed, and each of them begins to manufacture its own particular chemical product. Working in harmony they pour their internal secretions or hormones into the circulation, which carries them to all the organs in the body. They are the executive officers of the body, and their function is to see that the 'orders' of the genes are carried out. Thus they see that the sex apparatus, the size of the body, the colour of the hair, skin and eyes, are all developed according to the specifications of the genes. But, as we snall see presently, they don't always complete their job properly.

One of the most obvious examples of the effect of glandular activity is provided by the sex glands themselves, the testes and the ovaries. These become active at puberty, and their hormones are then responsible for what are called the secondary sexual characters. Their activity accounts for the breaking of the voice and for the development of the breasts in the female and of the beard in the male.

The Genital Organs

One of the most remarkable features of development is the way in which the genital organs are formed. The astonishing thing about them is that the rudiments of both male and female genital organs appear in every individual. Not only that, but some of these are retained in vestigial form in the adult body. For example the male nipple represents the female breast, and the miniature uterus masculinus of the male represents the womb.

As to which of the two sets of genital organs is to be developed, there is no doubt that the decisive say rests with the genes which are on, and with those which are associated with, the sex chromosomes.

This dual nature of sex anatomy makes it easier to understand the all too frequent examples of the imperfect differentiation of sex resulting in anatomical abnormalities of the sex organs. In sex diagnosis these cases of pseudo-hermaphroditism or intersex present a problem to which the correct answer can only be arrived at after taking account of the genetic constitution of the cells of each case and of the other factors for sex that have been discussed above.

The question whether it is advisable or not to 'change the sex' of an individual, that is to say to correct a previous wrong diagnosis, frequently crops up, and requires careful consideration, especially if the case is that of a grown-up. The difficulty arises from the fact that many of these cases are quite happily adjusted to their wrong sex, so that it is better to leave well alone.

The classical example of the way in which the hormonic influences to which the foetus is subjected may upset the genetic determination of sex is provided by the 'free-martin' in cattle. This is a cow which as a calf shared a placenta, and therefore the blood, of a twin brother. As a result its constitution is so masculinized that it is sterile and shows male propensities.

Recently Wilkins *et al.*[2] reported a series of baby girls who were born in a masculinized condition because their mothers were treated with the female hormone, progesterone, while carrying them.

Interesting in a somatic direction as showing the influence of the mother's hormones on the genes is what happens when the small donkey species is crossed in different directions with the horse species. Although in both cases it is the same genes for smallness on the one hand and for bigness on the other that are involved, the resulting mule tends always to take the size of the mother. The same phenomenon is encountered in the canine world, where small bitches which have been accidentally mated with much bigger dogs don't necessarily have difficult confinements.

From the evolutionary point of view the importance of the anatomical duality of sex in each individual (referred to above) lies in the fact that it shows that sex is not an absolute but only a relative quantity. It explains why there are degrees of sex, why there are mannish women and effeminate men, and it goes a long way towards explaining the perversions of sexual behaviour.

That the imbalance in the mechanism of sex inheritance and the interplay between masculinism and feminism have also exercised an important influence on human evolution cannot, I submit, be doubted. The anatomical evidence of feminism is there, and I think we must agree with Darwin that the best in human emotional life is that part which came from those primitive maternal instincts that the female developed for the rearing of her family. Of course, however, it is not contended that anatomical feminism in the human male curbed to any great extent his inherent psychological masculinism. The coming of Man was not the end but merely the beginning of a different and equally cruel struggle for existence. We know the fierceness of the struggle which prehistoric Man had to contend with in defying the elements of heat and cold and in providing food for his family. History is a vast chronicle of successive wars, none the less bloody for having been sublimated into the priceless cultural shapes of literature, art and music.

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