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A Study of Intersexuality as Exhibited in Animal Forms

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A STUDY OF INTERSEXUALITY AS EXHIBITED IN ANIMAL FORMS

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PREFACE

In the following discussion on "INTERSEXUALITY AS EXHIBITED IN ANIMAL FORMS", it is not my purpose to give a detailed account of any one type of intersexuality, but rather to show the scope of the entire subject. I have endeavored to use as examples those forms which best illustrate a certain type.

However, there is not much material available, and I have based my work on that of Crew and Lipschutz, both of whom have done splendid work in this field. Among other leaders are Steinach, Goldschmidt, Lillie, Goodale, Tandler and Gross.

A STUDY OF INTERSEXUALITY AS EXHIBITED IN ANIMAL FORMS

What is sex? Among the fundamental principles of biology reproduction is recognized as a primary characteristic of living matter. In the simplest unit, the cell, reproduction is a common function and in complex organisms every individual plays some direct part in the production of new individuals unless it is specialized for other purposes in a colony of different kinds of individuals. In the lower organisms, reproduction is carried on asexually by means of budding, sporulation and gemulation. Between this and sexual reproduction, however, there is a great gap, for the formation and union of gametes demand a differentiation of reproductive cells which the simpler processes of asexual reproduction do not require. In the simplest forms of sexual reproduction all individuals are apparently the same and the gametes which they produce show few or no differences. In higher organisms the female gamete becomes more and more specialized as a passive cell in which food for the developing embryo is stored, and the male gamete is a highly specialized motile cell, unhampered by stored food and therefore possesses the maximum ability to seek out the egg cell.

Among the more primitive organisms and among some higher species, differentiation of the individuals producing the two kinds of gametes is conspicuously lacking even to the extent of hermaphroditism. This I shall later discuss more fully.

In the higher animals, however, and in some of the higher plants, complete separation into male and female sexes is accomplished, each of which produces only one kind of gamete. Sex, then, is that term used to define that differentiation of different parts of an individual which is associated with the elaboration of physiologically and often morphologically dissimilar gametes in the union of which the next generation has its origin.[1]

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1. F. A. E. Crew, The Genetics of Sexuality in Animals (N. Y., 1927) p. 1

Both male and female, in addition to the production of gametes, possess certain secondary sexual characters whose importance can not be magnified. All differences between sexes other than the primary differences of egg and sperm production are called secondary sexual characters.[2] The fundamental sex differences are therefore usually accompanied by marked diversity in size, general metabolism, instincts and structures involved in mating or fertilization; and in such characters in animals as combs, horns, hair and plumage, the development of which is influenced by the presence of the sexual glands, which are chemical substances secreted by certain cells of the ovaries or testes.

The modification of these secondary sexual characters by internal secretions, or their absence, sometimes produces individuals intermediate between typical males and females, called intersexes. Some forms are occasionally found in nature, and in some cases produced by hybridization. In some intersexes, the modifications are so great as to interfere with reproduction. Not only external characters, but ovaries and testes themselves may be greatly altered in the direction of the opposite sex. Even the sexual behaviour is changed.

In the lower animals we do not find many examples of true intersexuality, but hermaphroditism is quite common. To distinguish between intersexuality and hermaphroditism: Intersexuality is the state or quality exhibited by an individual of a normally dioecious group in which both male and female-ness are to be distinguished in varying degrees and, or at different times. Hermaphroditism is the expression of a sexuality normal to a particular group, that is, a state of being monoecious; intersexuality transient or permanent, an expression of sexual abnormality in a particular group or individual. Hermophroditism and intersexuality are the same expression of self-same mechanism, but whereas intersexuality is perfect or imperfect hermaphroditism in a non-hermaphroditic group or individual, hermaphroditism is perfect intersexuality in a group or individual

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2. Horatio Hackett Newman, Readings in Evolution, Genetics and Eugenics. (Chicago, 1921) p. 454.

in which such a state or quality is a customary feature of a normal life history.[3]

The majority of lower animals, sponges, worms, etc. are true hermaphrodites, and this condition appears to be in relation with their more or less fixed mode of life. As a rule testes and ovaries occur in the same animal but different regions of the body. Hermaphrodites may be classed as non-functional and functional. Non-functional hermaphroditism is the condition in which, though both male and female germ cells are elaborated transiently or permanently, only one kind is functional. It exists in three forms:

1. ACCESSORY -- in addition to a testes a rudimentary ovary is found which, however, does not produce ova, e. g., Bidders' organ in the male toad; the ovary in the male of the stone fly, Perla marginata.
2. ACCIDENTAL -- ova occur sporadically in testis and spermatic tissues in ovary. It is not uncommon among the Crustacea. It shows that the primordial germ cell can, under different circumstances, develop into sperm or ovum.
3. TERATOLOGICAL -- the reproductive system consists of an intimate mixture of male and female organs.

Functional hermaphroditism is the condition in which both sperm and ova are produced by the same individual, and both are functional. It, too, exists in three forms:

1. In UNISEXUAL MONOECISM a genetic male or female develops at certain times ova in the testes or sperm in the ovary and the individual previously functioning as a male now functions as a female. (Nematodes and molluscs) One sex has now become hermaphroditic. Gynomonoecium (female producing male) is more common than andromonoecism. (male producing female.)

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3. F. A. E. Crew, The Genetics of Sexuality in Animals. (N. Y., 1927) p. 68

2. In CONSECUTIVE MONOECISM every individual is at first a male and then a female, or vice versa, which is less common. Genetically the organisms are either males or neutrals. This condition is associated with parasitism and sedentary modes of life, e. g., Danalia, one of Tereopsidae, is parasitic on parasitic Rhizocephalan Crustacean.

3. In SPATIAL MONOECISM the male and female reproductive organs are present and the condition is real functional hermaphroditism. e.g.,Oligochaetes, Cestoda, Trematoda.[4]

The annelid, Lumbricus, terrestris, provides an excellent example of true, functional hermaphroditism. Although it is monoecious, the eggs of one are fertilized by sperm of another, and therefore its reproduction is extremely interesting. The bodies of two worms are closely applied by ventral surfaces, the heads pointing in opposite directions and the clitellum of each worm is approximately opposite segments seven to twelve of the other worm. Each worm secretes a slime tube which encircles the body from segments eight to thirty-three. The sperm are discharged from spermaducal pores into the space bounded by the slime tube and the body of the worm. Here sperms form irregular masses or spermatophores which are carried backward within the slime tube by muscular contractions of the bodies of the worms and finally picked up by the seminal vesicles of the other worm.[5] Thus exchange of sperm is effected. This, however, is rare, for monoecious beings are usually self fertilized if they are not sterile, or are at all productive.

In the nemotode, angiostomum (Rhabditis) nigrovenosum, a form characterized by alternation of generations between a free living dioecious form and a parasitic hermaphroditic form that lives in the lung of the frog, Boveri and Schleip give ←

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4. Encyclopedia Brittanica, Vol. II. XIV Edition. p. 503

5. A. Franklin Shull, Principles of Animal Biology (N. Y., 1920* pp. 184,185.

a plausible explanation in which the existence of sex chromosomes or of any connection between chromosomes and sex production is established. In the dioecious form the male and female occur in nearly equal numbers. Fertilized eggs develop into parasitic hermaphroditic forms having the general morphology of a female, possessing ovaries and producing oogonia, but later spermatogonia, the two being formed in irregularly alternating zones. Eggs and sperm are produced and self fertilization takes place, producing freeliving males and females in equal numbers. In the parasitic generation the diploid number of chromosomes is twelve. During spermatogenesis one half the sperm receive six, one half, five, owing to the fact that the sixth remains near the equator and degenerates. There are two kinds of embryos, those having twelve chromosomes, and those having eleven. The males of the dioecious generation have eleven. As a result we would naturally expect the hermaphroditic females to have twelve chromosomes, and the males eleven, but all fertilized eggs produce hermaphrodites with twelve chromosomes. The probable explanation is that the five-chromosomal class may be non-functional and degenerate. Therefore the true hermaphrodite should not be regarded as a mere composite of male and female, but as a result of a definite genetic complex analogous to that which by mosaic-like patterns of pigments are determined in other organisms; and same in principle is true of the closely related phenomena of intersexuality.[6]

I have already defined intersexuality as being the state in which qualities of maleness and femaleness are exhibited by an individual either at the same or at different times. There has been much controversy concerning a gene for intersexuality. Sturtevant has shown that there is a single recessive chromosome II gene which, when in duplex state, turns females into intersexes and renders males sterile. The matings between the stock that gave intersexes and others that did not, gave no intersexes in the F_1 generation but these appeared in the F_2. The

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6. Edmund Beecher Wilson, The Cell in Development and Heredity (N.Y., 1928) p. 810

interbreeding of the F_2 gave five hundred ten females, one hundred sixty five intersexes and seven hundred fifty four males -- an excess of males and a 3:1 ratio in respect to sexual normality and sexual abnormality. His work was done with Drosophila simulans. In mating three F_1 females out of an intersex x plum mating, he obtained the following results in F_2:

♀		♀♂		♂	
Wild-type	plum	Wild-type	plum	Wild-type	plum
198	91	87	0	293	65

There was no intersex plum class, showing that these characters are linked and the genes are resident in the one and same chromosome.[7] This gene for intersexuality means certain organization of chromatin in a particular area of a particular chromosome different from usual.

According to Crew, intersexuality in a normally dioecious group will follow upon disharmony in the sexual genotype of the body as a whole or of local parts. He states the Time Law of Intersexuality as -- those organs first to be developed and differentiated are the last to be modified; those that appear last, the first to be changed. Since an intersex is an individual that has developed as a male (or female) up to a certain point in its life history and thereafter has continued its development as a female (or male), the degree of intersexuality is determined by the time during the critical period of sexual differentiation at which this switch-over took place. A genotypic female develops ovaries because she is genotypically a female and is not a genotypic female because she has ovaries. A phenotypic female is that because she has developed ovaries. The first stage in sexual differentiation is the formation of ovaries or of testes from undifferentiated gonads. Secondly, under the direction of hormones produced by testes or ovary, Müllerian or Wolffian ducts continue development to become functional accessory sexual apparatus and later secondary sexual characteristics appear.

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7. F. A. E. Crew, The Genetics of Sexuality in Animals (N. Y., 1927) pp. 45, 46

Intersexuality may be due to abnormality at the time of differentiation of gonads or pseudo-intersexuality. A goat case is recorded where as a young female, it won a prize, yet later exhibited male characteristics -- its beard grew, its head became male-like, in its behaviour it resembled the "Rig", a male with mal-descended testes, but its external genitalia retained the form of a vulva-like operture with an over-large clitoris. When the internal genitalia are examined, there are shown paired gonads lying in the situation of ovaries. The accessory sexual apparatus is composed of epididymes, vasa deferentia, seminal vesicles, prostate, cowper's glands, uterus and vagina.

In a number of cases of pigs which Crew examined, all fell into one of two classes: (1) those in which no morphological evidence of previous or present existence of ovarian tissue could be found in the gonads. They were entirely composed of testicular tissues with histological structure varying with the position of the testes along a line between a primitive position and scrotum, but always exhibiting some degree of degenerative change. (2) Those in which both ovarian and testicular tissues were present. As to gonads -- one was ovary, the other testis; one ovary, other ovatestis; or both ovatestis.

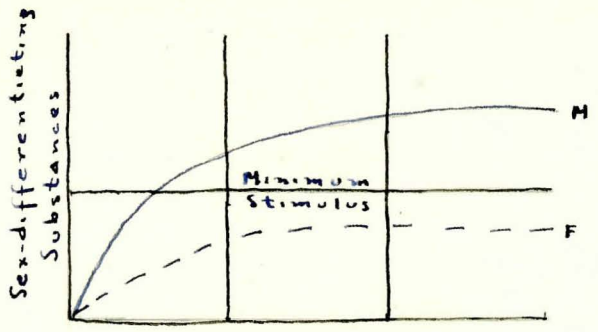
In class 1 there were paired maldescended testes, more or less well developed derivatives of both Mullerian and Wolffian ducts, external genitalia ranging from those of an apparently normal female to those of a grossly imperfect male. These can be interpreted most readily as instances of abnormal sexual differentiation in the genotypic male, the following assumptions being made:

(1) The stimulus to differentiation of the remainder of the sex-equipment is, in the mammal, localized in the gonads.

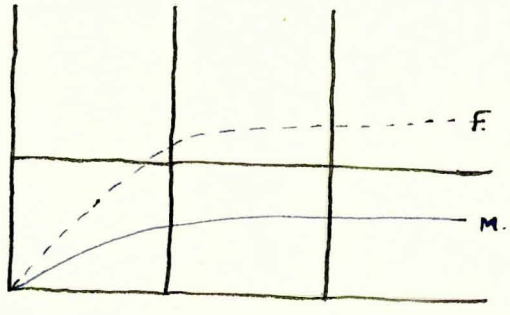
(2) Abnormalities pertain only to the earlier stages of sexual development.

(3) The influence of the gonad in the mammal at this stage is such as exhibits further development of these structures of accessory sexual apparatus appropriate to alternative functional sex, and these structures, in absence of such inhibition, continue to develop, unchecked.

PERIOD OF DIFFERENTIATION OF GONADS*



In the normal male, the male-differentiating reactions are effectively in excess during the whole period of gonadic differentiation, and so the gonads assume the structure of testes.



In the normal female, the female-differentiating reactions are effectively in excess during the whole period of gonadic differentiation, and so the gonads assume the structure of ovaries.

* F. A. E. Crew, The Genetics of Sexuality in Animals, p. 89. N. Y., 1927.

(4) There exists different threshold of response to sex-differentiated stimulus on the part of different structures of the sex-equipment and at different times during the development of the one and same structure.[8]

The cases in class 2 are instances of as perfect intersexuality as is possible in mammals. The cases are similar to those examined in class 1, save that the gonads include both ovarian and testicular tissue. To interpret these cases of glandular hermaphroditism, it is necessary only to explain the presence of both kinds of gonadic tissue since abnormalities of accessory sexual apparatus and of external genitalia can be explained most simply and yet quite satisfactorily by assuming that they are exactly the same in nature and in origin as those found in the intersexual male of class 1. In the pig the relation of ovarian and testicular tissue is remarkable. If testicular tissue is present in one gonad, testis or ovatestis, an epididymis and vas deferens will be found associated with it, but if the other gonad is an ovary, no epididymis and no vas will be found on this side. More than hormone stimulus is involved, and it would seem that some mechanical stimulus for maintenance of epididymis and the vas is supplied by the testis but not by an ovary.

Crew also states that intersexuality may be due to the overriding of the genotype or physiological intersexuality. This is best explained by the cases of the free martin in cattle and in the opossum. Keller and Tandler (1916) in Austria and Lillie (1916, 17, 23) in America, have done much to further knowledge about the free martin in cattle. They state that it gives much support to the assumption that intersexuality may be caused during embryonic life by simultaneous or successive influence of hormones of both sexes on the soma. Sometimes female twins in cattle show abnormalities in sex characters. These are known

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8. F. A. E. Crew, The Genetics of Sexuality in Animals (N. Y., 1927) pp. 45, 46

as free-martins and are sterile even when the external genitalia seem well developed; sometimes there are abnormalities also in the external genital organs, the clitoris being enlarged and transformed into a penis-like organ. A more detailed examination reveals a marked abnormality of the internal genital organs, whereas externally the animals resemble "Castrates". There is a great variability in the condition of the internal genital organs. The ovaries are in general rudimentary, resembling in some cases rudimentary testicles. The uterus is as a rule underdeveloped, being small and thin. According to Keller and Tandler, underdevelopment of organs originating in the female from Mullerian ducts is particularly marked when the rudimentary gonad resembles a testicle. In these cases ducts of Gartner (the remains of Wolffian ducts) are particularly well developed, giving the impression of vasa deferentia. In some cases there is even partial descent of the testis-like gonads. Some kind of seminal vesicles can be detected and are especially well developed if the other genital organs are of a more male type. Thus we see that the free martin is a case of intersexuality, showing a combination of characters of both sexes, those of the female being as a rule more marked.

It is well known that when both twins in cattle are of the same sex, both are normal; but when the twins are of different sexes, the male is always normal whereas the female one is normal only in rare cases, only in 6%. Is there any structural difference in the mutual relations between the foetuses which could explain why the female twin is generally abnormal, but is nevertheless normal in some cases? After a detailed examination, the conclusion was reached that the female foetus has abnormal internal genital organs, when there is a fusion of the two chorions and a well developed connection between the blood vessels. On the other hand, the female foetus was found to be normal when there was no connection with the blood vessels of the male foetus.[9] It also seems very probable

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9. Alexander Lipschutz, The Internal Secretions of the Sex Glands (Baltimore, 1924) p. 384.

that the male hormones pass into the blood of the female and thus cause masculinization of the female twin. Then, during extra-uterine developments, when this influence of the male sexual hormones ceases, the free martin appears to acquire the body proportions of an ordinary castrate.

Hartman and League (1925) in examining an opposum brought in as a male, found on closer inspection that it possessed skin folds, simulating a pouch, better developed than in a normal male. The penis was of normal size and structure, the scrotum well formed but empty and the head of male type. The internal genitalia consisted of accessory sexual apparatus of infantile female type. All parts of the Müllerian duct were present, vagina, lateral vaginal tubes, uteri and Fallopean tubes. The glands were infantile in dimentions and structure. There were no vasa deferentia and the Wolffian duct derivatives were absent. The gonads were in the position of ovaries and small. Although the authors could not prove their contention that this abnormal individual was a male rendered abnormal in utero by the action of sex hormones of a normal female co-twin, they presented certain evidences in favour of this interpretation.[10]

How far is any abnormal condition of the endocrine function of the sex gland or of some other internally secreting gland involved in intersexuality? True glandular intersexuality is not uncommon in such species as pigs and goats. Pick (1916) examined half a million pigs in a Berlin slaughter house and six cases of true glandular hermaphroditism were found. The internal genital organs were intersexual -- ovariotestes, while both uterus and vasa deferentia were developed. In some external genitalia were feminine, others masculine and some decidedly transitional between male and female. The ovary and testicle could be recognized. The seminal tubules were in an infantile stage, but the quantity of interstitial cells was very great. The ripening of the follicles had been going on in the ovary. Observations show that where ovary and testicle are present, there is also somatic intersexuality. It is probable that in some cases, the ovary was on its way to disappear, or, in an intersexual individual, the gonad

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10. F. A. E. Crew, The Genetics of Sexuality in Animals (N.Y., 1927) p, 103

of one sex may disappear, the intersex gland thus being transformed into a monosexual one -- with the result that an individual belonged to the group of pseudohermaphrodites with a gonad of one sex no longer corresponding to the intersexual condition of the sex characters.[11]

Bujard (1921) says that bilateral glandular intersexuality is much more common than is generally admitted. The fact is overlooked that the ovarian part of the ovariotestis may be reduced so as to be found only when a careful histological study is made. Cases where the genital organs consist of a hypertrophied clitoris, vasa deferentia, seminal vesicles, prostate, uterus, vagina, the gonads microscopically resembling retained testicle, underdeveloped seminiferous tubules and interstitial tissue sometimes hypertrophied, can be explained as having been primarily glandular hermaphrodites in which ovarian endocrine tissue has afterwards disappeared.

Krediet (1921,22) describes a true ovariotestis. Internal genital organs were feminine, there was also an epididymis. The goat was seven years old, gave plenty of milk, but had a general male appearance, had bisexual behaviour and the smell of a male. Genital organs, beside being feminine with the ovariotestis, contained ova and spermatogonia.[12]

Steinach (1920) describes a goat with normally developed female sex characters, but with a decidedly male sex behaviour. There were no signs of heat. Later on the skull became broader than that of the female. The animal was killed at the age of ten months. The genital organs were female and there were ovaries in their normal places. Microscopical examination revealed that the ovaries were really ovariotestes. Primarily female endocrine glands of the ovariotestis dominated over the male and the female sex characters such as the vagina, uterus and mammary gland could develop normally. But the function of the female gland was impaired and the male gland was activated; a male erotizing influence on the

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11. Alexander Lipachutz, The Internal Secretions of the Sex Glands,(Baltimore, 1924) p. 380

12. Ibid. p. 381

central nervous system and male influence on the growth of the skeleton then took place.[13]

Homosexuality in man we are inclined to ascribe to female sex hormones being present and active. There are many cases where there is a periodic change in psycho-sexual behaviour. Steinach found that interstitial tissue contained large epithelial cells, not resembling the ordinary male interstitial cells of the testicle, but rather the luteal cells of the ovary. However we have no proof for this beside Steinach. Of the recent cases of intersexuality described by Bab (1920) Benda (1921) and Blair Bell (1920), the majority belong to the class of pseudo-hermaphroditismus masculine externus. The external sex characters, in these cases, are feminine, although some traces of the male may be present. The internal sex characters are either male or underdeveloped female. The gonads in general are found to be underdeveloped testicles in which seminal tubules in an infantile stage were to be found. The discrepancy is found to exist between the sex of the gonad and that of the sex characters. For that reason most of the authors are opposed to the assumption that hormonic intersexuality is involved, since the sex gland is secreted by gonadal tissue.

Cases of real hermaphroditism are extremely rare in man. In the cases of so-called glandular hermaphraditism, the hormonic basis, it is suggested, may be an adrenal or gonadal one. There is more chance that the sex glands will be monosexual, an almost complete transformation of the gonad into the opposite sex having taken place and if this is true the chances of observing glandular intersexuality will be greater. However, if the hormonic basis is adrenal, it does not mean that the adrenals have a direct masculinizing or feminizing effect on sex characters for the primary effect seems to be masculinization of the sex gland by the intermediation of which the masculinization of sex characters takes place. [14].

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13. Alexander Lipachutz, The Internal Secretions of the Sex Glands, (Baltimore, 1924) p. 381.

14. Ibid. p. 378

Is hypospadia a symptom of intersexuality? It is explained either as being due to masculinizing hormones during embryonic development entering into play, or becoming activated after the soma had originally begun its sexual differentiation in a female direction. There would be masculinization of a soma which had already undergone the influence of female sexual hormones, female sexual characters had already become fixed to a certain degree. The degree of hypospadia will depend upon the time at which the male sexual hormones became activated and the female sexual hormones ceased to be active. Therefore hypospadia may be a sympton of intersexuality which existed only during the embryonic life of an individual when simultaneously or successively male or female sex hormones exerted their influence on the soma. In that case, it is really temporary intersexuality. If we adopt the view that a hypospadic individual is an intersex, the number of intersexes greatly increases. In France there were five cases of hypospadia in one thousand recruits. (Neugebauer 1908).[15]

Steinach contends, however, that intersexuality is caused not by the simultaneous presence of male and female generative cells, but by the simultaneous presence of special endocrine glands. As to pseudo-hermaphroditism, he assumes that in the many cases where homologous and heterologous sex characters are combined in an individual, although the gonads seem to be of only one sex, they are of one sex only in the matter of generative cells, and are hermaphroditic in regard to endocrine cells, these gonads containing in reality an hermaphroditic puberty gland.[16] Such a suggestion means no justification for classifying cases of intersexuality as true and pseudo; both would be true.

Sex reversal in birds might often be mistaken for intersexuality. Cock-feathering or virility has been observed in twenty-six different species of birds. This is evidently due simply to the ovary becoming inactive or insufficient, often a climacteric change or a change due to some other cause inhibiting the hormonic activity of the ovary. Thus the bird assumes characters of the neutral form,

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15. Alexander Lipachutz, The Internal Secretions of the Sex Glands, (Balt. 1924)

16. Ibid. p. 366

but there is no sign of intersexuality. One can speak of intersexuality in fowls, only if there is, in addition to an assumption of male plumage, an increase of head apparel or a change of sexual instincts. Hartmann and Hamilton (1922) have described a new case of true hermaphroditism in the fowl. The plumage was female, spurs were present and the head apparel was developed as in a male. Sexual behaviour was intersexual, the bird sometimes crowing like a cock, and clucking like a laying hen. It once laid an egg. A testicle and an ovariotestis were found. In the ovarian part interstitial and luteal cells were present. Sperm were found.[17]

Gynandromorphism, a kind of intersexuality, is an abnormality in which one side of an individual has the characters of a male, the other of a female or a gynandromorph is an individual of bisexual species which exhibits a mosaic of male and female sexual characters. Crew thinks it results from an aberration in distribution of the chromosomes, and the later this aberration occurs, the smaller will be the area it affects. Boveri contends that it results from a condition of partial fertilization in which the sperm does not fuse with the egg until the 2-cell stage or later. Therefore some cells are of purely maternal origin (haploid constitution) while those from the fusion nucleus may be 2x and are of biparental origin. We thus expect the haploid to show female and the diploid, male characteristics, the particular pattern depending upon the period and place when the fusion nucleus is formed.[18] Drosophila is an excellent example. Crew found that in Drosophila melanogaster, one in every two thousand individuals exhibits this condition of gynandromorphism. Most of these exhibit complete male characterization on one side of the anterio-posterior mid-line of the body, the complete female characterisation on the other, with a sharply demarcated line of junction of the two kinds of tissue. Since the male body is normally smaller than thatof a female, the body is bent toward the male half. Usually in these cases there

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17. Alexander Lipachutz, The Internal Secretions of the Sex Glands, (Baltimore, 1924) p. 392.

18. Edmund Bucher Wilson, The Cell in Development and Heredity, (N. Y., 1928) p. 812

is an ovary on the female side, a testis on the male, but this is not always the case, for Huettner (1922) has shown that the gonads are not formed from a single nucleus but from several nuclei which give rise to the primordial germ cells, and so it is not inevitable that both gonads should be histologically and cytologically similar. Commonly, however, there are two ovaries or two testes in a bilateral gynandromorph. In other cases of gynandromorphism one quarter of the body is male in its sexual characterisation, three quarters female, in still others less than a quarter is male while more rarely the head is female whilst the rest of the body and abdomen are male.[19]

Morgan and Bridges (1919) have described many of these sexually abnormal forms in great detail and have shown that if in the mating that produces the gynandromorphic forms sex-linked characters are involved, and if the sex-linked characterisations of the two parents are dissimilar, then the sex-linked characters of the male parts are those exhibited by the father or those exhibited by the mother whereas the sex-linked characters of the female parts are a combination of the sex-linked characters of both parents, and that, in respect of the autosomal (non-sex-linked) characters, male and female parts are alike.[20]

And now we come to perhaps the most interesting phase of the entire subject -- that of experimental intersexuality. Much research has been done, but is is yet a comparatively recent undertaking. Therefore I can only present here the work of some of the most reliable scientists in this field.

Steinach and Sand experimented independently and found that the simultaneous presence of male and female sex glands in the same individual can transform the latter somatically and psychically into an intersexual individual. The results in brief of Steinach's experiments in the transference of the sex gland to young castrated animals of the opposite sex are (1) masculinization of female animals

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19. F. A. E. Crew, The Genetics of Sexuality in Animals (N. Y., 1927) p. 26

20. Ibid, p. 27

by implanted testes (2) feminization of young male animals by implantation of the ovary with corresponding results. The young female afterwards developed into a male-like animal by somatic change -- weight, length, etc. psychic and sexual behaviour. He was however, unable to obtain either growth or persistance of the implanted sex glands unless the gland of the host was removed before the implantation. Observations show definitely that the sex gland can be successfully transplanted to an animal of the opposite sex which retains one normal gonad. He found, too, that there is a definite antagonism between the ovary and testis. An ovary implanted in an ordinary male and a testis in an ordinary female will not take, and will not function in the new host but will undergo resorption. This can be overcome if the host is previously castrated and both testis and ovary are engrafted simultaneously. The chance of the survival of ovarian graft seems to depend upon the quantity of testicle simultaneously present in the body, and the time of latency of feminine hormonic effect surely depends upon the quantity of testicular tissue. There is an antagonism existing between the gonad in situ and the engrafted gonad. It is not definitely known if the antagonism is antagonism of hormones simultaneously circulating in the body.

Krediet unilaterally castrated a goat a few days old. The gonad was an ovaristestis. Four months afterwards he removed the second gonad, an ovariotestis without spermatogonia, the testicular part being in a state of atrophy. He thinks that the second gonad changed during the four months which had elapsed since birth, and says that this animal, which during youth was a true hermaphrodite, would afterwards have possibly become a female individual.

Goodale, in castration of fowls had negative results. He castrated nine young cocks unilaterally and engrafted ovaries. After sexual maturity was attained the birds were killed and in seven cases ovarian tissue could not be detected. Even those in which ovarian tissue was found showed somatic psychic masculinity. He obtained the same results with hens.[21]

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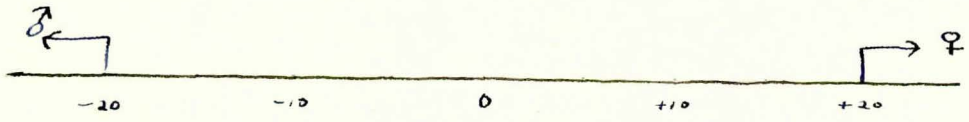
21. Alexander Lipschutz, The Internal Secretions of the Sex Glands (Baltimore, 1924) p. 357

Goldschmidt has presented an extremely interesting case of experimental intersexuality, using the European and Japanese species of the gypsy moth for this purpose. Insect breeders have long known that in crosses of species as well as of geographic varieties a comparatively high percentage of sexual abnormalities are produced. A European made x Japanese female produced normal offspring whereas a European female x a Japanese male produced all normal males, but all females showed in all parts of their bodies admixtures of male characters. He first called these animals gynandromorphs, but as this term is usually applied to animals with bilateral or antero-posterior or similar mosaic of two sex characters, it seemed advisable to use another term, that which represents a definite step between the two sexes, an intersex. The F_2 of this breeding gave normal and intersexual animals. When the experiments were repeated, different results appeared. The material used came from different strains, and the suspicion arose that there are many different races of gypsies, different in regard to those things which are responsible for intersexuality. The suspicion strengthened when it became probable that the peculiar thing responsible for intersexuality could be influenced by external conditions. The conditions in Japan ought to be very favorable for an origin of such racial variation as Japanese isles show a climate varied from an almost arctic to an almost tropical. He has evolved the following diagram.



All individuals to the right of + 20 are females; all those to the left of -20, males; those between are either intersexual males or females.[22]

To illustrate the different degrees of intersexual females:

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22. Richard Goldschmidt, The American Naturalist. Dec. 1916, p. 708

1. +15 -- a Japanese male G x Japanese female K produced females that were slightly intersexual. The antennae were feathered but less than in the male, a portion of the wings assumed the brown color of the male. Not as many eggs were present as in a normal female, but the mating instincts as well as the copulatory organs were still female and the eggs could be normally fertilized.
2. An European female F x Japanese male G produced a lower female intersex. All secondary sex characters were more male-like; the instincts were still female and the animals attracted the males and mated. One of the characteristic hairy egg sponges would be laid, but it contained no eggs, only hairs. The copulatory organs were changed already in the direction of a male and no successful mating and egg deposition was possible, although the abdomen was filled with ripe eggs.
3. An European female F x Japanese male G produced an intersexual female which was more than half way between male and female. The secondary sex characters were almost male. The instincts and behaviour were about intermediate between the sexes. The male was scarcely attracted and no mating occurred. The copulatory organs show a strange combination of the male and female, but there are still typical but rudimentary ovaries left.
4. An European female F x Japanese male x produced individuals that were externally almost indistinguishable from a true male. Certain characters, especially copulatory organs still show female origin. The instincts were entirely male and attempts were made unsuccessfully to mate with the female. The sex gland was extremely interesting, it looked externally like a testis but showed in secretions every single step between an ovary with nothing but immature eggs

through a mixture of ovarian and testicular tissue to a real tissue.

Likewise have different intersexual males been produced, showing corresponding degrees of male intersexuality.

In this paper I have tried to give a brief but comprehensive view of Intersexuality and the different phases in which it is found. At the very bottom of the scale we have the perfectly normal monoecious animals, such as the sponges, worms, etc., of which the reproduction of the earth worm is an excellent example. There are two types of hermaphroditism, non-functional and functional, each of which exists in three forms. Certain semi-parasitic nematodes show a peculiar method of adopting themselves to hermaphroditism by the degeneration a sixth chromosome. As we progress to the higher animal phyla, we find more complicated and less easily defined cases of intersexuality. The common opinion is that intersexuality is closely allied to abnormalities occurring in the early formation of gonadal tissue and the functioning of the sex glands. Experimental intersexuality has gone for to prove this current view point. However, the entire subject is comparatively unexplored and untestes, and as time progresses, we shall undoubtedly have these now seemingly incomprehensible problems made as intelligible to us as the forward development of the subject of Genetics in recent years has enlightened us on sexuality.

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