

Gynandromorphs, Mosaics & "Half-Siders"

by George A. Smith
Broadway Veterinary Clinic
Peterborough, Cambridge, England

The name gynandromorph (meaning in shape both male and female) is given to those curious creatures whose body halves seem to be of different sexes. Although, in at least one text book on genetics, gynandromorphs have been called "half-siders," we shall see later that there are Budgerigars that, although they have sides of different colors, are not sexually divided. Therefore, we shall restrict the term gynandromorph to those cases where the sexual division goes straight down the middle of the body. Such a separation is so precise that it looks just as if someone had severed the members of a sexual pair into two longitudinal halves, then skillfully joined their separated halves together to make two mirror images.

Although gynandromorphs are best known in butterflies, moths and other insects, they have been recorded in several vertebrates. A lovely demonstration in birds is the European Bullfinch *Pyrrhula pyrrhula* on display in the bird section near the school entrance to the American Museum of Natural History, New York. As the Bullfinch is highly sexually dichromatic, this monster has the right hand side of the belly, chest and cheeks pink (the male color), while the left is the female brownish-grey.

The cause of this extraordinary fifty-fifty gynandromorphy is that the first two cells to form in the earliest stages of embryo development differ in their sexual genetics. When, by cell division and growth, each produces its half of the body, one portion is male and the other looks female.

As this astounding early defect happens extremely infrequently (and because most of the few that occur wild will not be noticed by anyone), the avian examples tend to be of domesticated birds: mostly ducks, pheasants and poultry. Amongst the most bizarre must be a preserved bird in the British Museum, Natural

History at Tring. This skin is of the wide-ranging, highly sexually dimorphic, colony nesting grackle *Quiscalus lugubris*. In this species, the brown females are about three-quarters the size of the black males. This pied gynandromorph is, therefore, ridiculously lop-sized. The imaginative might get the impression that it had spent its life going in circles; for on its left it has a big, black wing, a long leg and a black body. On the right side they are partnered by a smaller brown wing, a shorter leg and a brown body. The tail, too, is asymmetric: the left half black and long, and the right brown and short. Another striking feature of this grackle is how the bill is curved sideways, to the right, because the bigger male half-portion of the beak bends over to accommodate the smaller female half.

Another particularly impressive gynandromorph was a caged Australian Eclectus. It would have been more unusual had not the mutation occurred slightly later than the first-cell division. Perhaps it took place at the four-celled stage? Although the body was absolutely split-colored (green on one side and blue and red on the other), the eclectus' head was almost wholly green as in a normal male. Such fractional gynandromorphs are scientifically known as mosaics.

Mosaics form at any stage in cell division. As the number of embryonic cells build up, the greater, obviously, will become the chance of one developing a "sex change" mutation. This is why mosaics are the most common form of gynandromorphy. Most of us will have seen at least one example as in a few patches of female feathers on an otherwise male-colored bird.

Obviously, a gynandromorph would not be discernable in a sexually monomorphic bird. However, they do show up in domesticated birds that are bred to reveal mutant colors. Such mutant, captive-bred

gynandromorphs are invariably known as "half-siders." The enormous numbers of birds reared in confinement ensures that there will be several examples produced every year. However, only some get to be reported. Recently I saw a "half-sider" Zebra Finch. The reason for the owner bringing the decomposing bird to my attention was not to demonstrate his curious, perhaps unique, possession; but because he wanted to know what had killed it. I have seen two "half-sider" cinnamon/normal canaries and have been told of a third.

In Cockatiels (*Nymphicus hollandicus*), there are two sequential 1986 Parrot Society Magazine reports (Smith: p. 60 - a color photograph is included - and Whitby: p. 266). The sex-linked genes involved were "pearl" and "cinnamon." The accounts are sufficiently detailed to prove their genetic structure.

By far, the most common "half-sider" parrot is the exhibition Budgerigar. Although I can recall several involving sex-linked genes (lutino, cinnamon, opaline and lacewing), the list also contains two where the bicoloration of the bird was blue and green. These were not gynandromorphs. The gene for blue is inherited as a recessive autosomal. One Budgerigar was wholly male (to have a completely blue cere) and the other female (with a brown cere).

An obvious question for anyone to ask about "half-siders," mosaics and gynandromorphs is: are they fertile? If they are, will they prove to be as true hermaphrodites as snails and earthworms to function as both male and female? Or are they, despite them seeming to have a female half, wholly male? Or, perhaps, they may have ovaries, not testes, and are female?

In answer, all the dozen or so "half-siders" studied by myself have been fertile males, producing the usual 50/50 ratio of male to female chicks. What they have never done is to yield further gynandromorphs.

The color of the chicks show that both testicles function in a "half-sider." One half of the father's body (with its contained testicle) is heterozygous ("split") for a recessive color gene. The other half of the body (with the second testis) is homozygous ("double factor") for the same gene.

Before explaining "half-siders," we must realize that each testis has

directly descended (by division and growth) from one of the first two cells of the fertilized egg. At conception, the "half-sider" yielding egg is homozygous ("double factored") for a recessive, color-determining gene. However, at the first cell division, one of these genes then mutates (reverts back) to the "normal," dominant state.

Although rare, there still are so many examples of "half-siders" it suggests that "reversed mutations" for color are not exceptionally infrequent. This idea is contrary to the teaching that genetic mutations are invariably quite haphazard and always of an extremely rare occurrence. The evidence, and not from just "half-siders" but mutations in

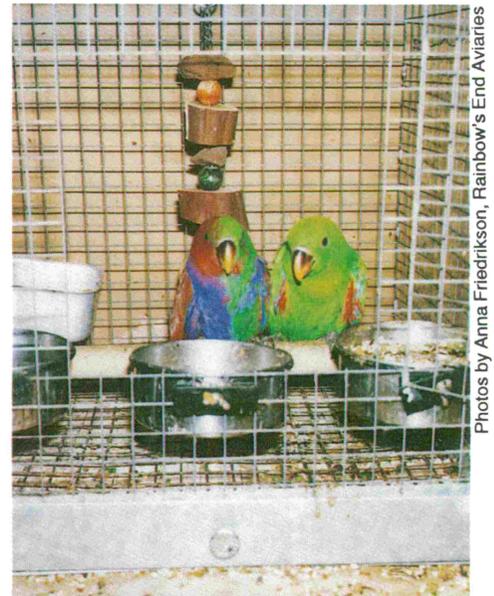
general, is contradictory. The fact is that certain genes seem exceptionally susceptible to allelomorphic change. Getting back to our example, the "palette" of color mutations in parrots proves always to be rather limited in range. It is not as broad as it would be were all mutations possible.

The consequence of this limitation is that color mutations do not form an infinite series. The same ones recur in all species of parrot. Perhaps not more than ten exist. Moreover, there is a "bias" even with these so that certain colors are far more likely to appear than others. Likewise, we know that identical "sports" occur in other avian Orders and that, again, these mutations match the parrots in their relative frequency. The "ino" (albino and lutino) mutation has been found in parrots as different as the Kakapo and Indian Ringneck; also it is one of the commonest recorded in penguins, Ostrich, Gouldian and Zebra Finch.

It may be that some alleles revert back to the "normal state" more readily than the "normal" alleles mutate. This might explain why "half-siders" occur more frequently than color mutations. The blue-green "half-sider" Budgerigars depend on an autosomal (not a sex linked) gene reverting back to normal.

This simplistic explanation, of "half-siders" being the visible consequence of a mutation of a recessive gene, may not necessarily explain wild-type gynandromorphs such as the bullfinch and grackle. To know what happens with these we would need a chromosomal analysis of cells taken from different sides of their body. Until this is done, I offer three (from many) possible explanations.

1. A single gene could be responsible for causing sexual dimorphism in some birds. Certainly, and this is despite the obvious difficulty in discerning such examples, there are a considerable number of cases where, in a sexually-dimorphic species, odd males turn up that are not externally distinguishable from their female counterparts. Likewise, there are a very great number of widely spread sexually dimorphic species that have one or more geographical races that are sexually monomorphic. If a simple somatic mutation were to occur at the two-celled stage in this hypothetical dimorphic-determining gene, this would give us a gynandromorph.



Photos by Anna Friedrikson, Rainbow's End Aviaries

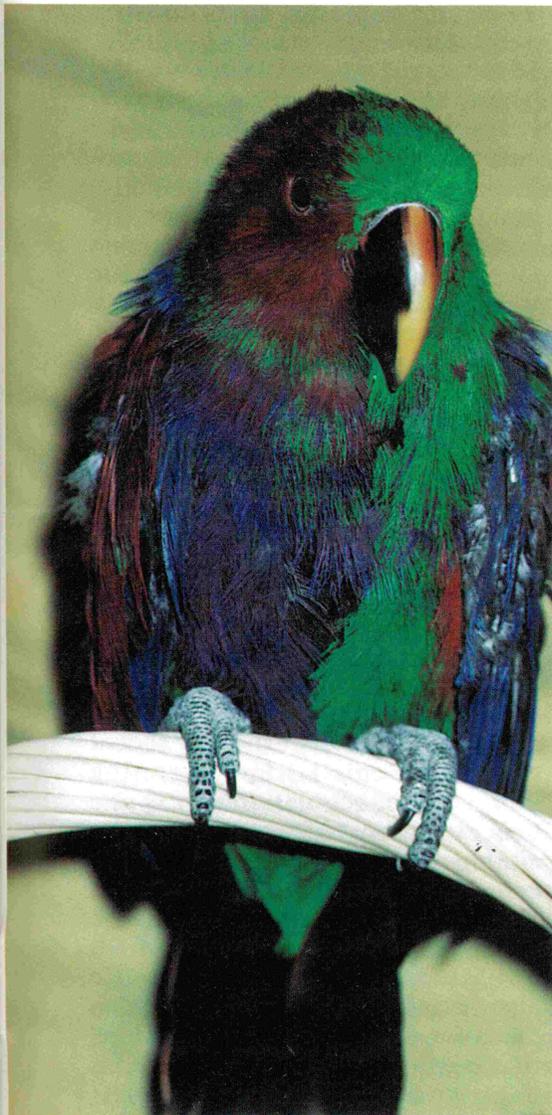
Johnny with male of true coloring on right.

2. In birds, the primary difference between the sexes is that males have two sex chromosomes ("XX") and females have but one (and a "Y"). Hens, therefore, are "XY". As "Y" is generally smaller than "X", it is considered to be almost genetically inert. So inconsequential is it that its absence does little or no harm to the cell. If we represent the absence of a sex chromosome by the zero symbol "0", then "XY" containing cells are, biologically, closely approximate to ones with "X0". Both "XY" and "X0" are "female" cells.

Very rarely the fertilized "XX" ovum is irregular in the way in which it distributes its sex chromosomes at the first cell division. In this uncommon event, one of the first two embryonic cells gets its correct "XX" and the other but one "X" and is "X0". Whether "X0" would cause an ovary to be present is doubtful; but it would give female coloration to that side of the body.

3. The complete loss (gain, fractioning and joining together) of a chromosome is a well-known phenomenon in genetics. An example of this gives our third explanation for gynandromorphism.

Rarely, a fertilized ovum has three sex chromosomes "XXX". In consequence, at the first cell cleavage, these separate so that one of the two cells into which it divides gets "XX" (normal male) and the other one "X". This latter "X0", as we know, behaves as "XY". Despite its different genesis, this gynandromorph would be indistinguishable from 2. ●



The "half-sider" or gynandromorph occurs very infrequently in nature. As can be seen in the photo of "Johnny," an Eclectus Parrot hatched and owned by Anna Friedrikson, the right side is colored as a female while the left side is colored as a male.