Evidence Indicating that the X and the Y or the Z and the W were Originally an Homologous Pair of Ordinary Chromosomes

Today, the X and Y of mammals and the Z and W of birds are totally different from each other in size as well as genetic content. Yet, it can be shown that the two were originally an homologous pair of ordinary chromosomes or autosomes. A broad review of the sex-determining mechanism of various vertebrates enables us to reconstruct, step-by-step, this process of sex chromosome differentiation.

a) The Absence of the Chromosomal Sex-determining Mechanism in Certain Teleost Fishes

As will be shown in Part III, the androgenic hormone-producing system (testicular interstitial cells) and the estrogenic hormone-producing system (ovarian follicular cells) share a common embryonic blastema. It may be surmised that in the total absence of the chromosomal (genetic) sex-determining mechanism, each individual vertebrate should develop into a functional hermaphrodite. Indeed, among the teleost fishes of today, synchronous hermaphroditism is a characteristic of the seabass belonging to the genera *Serranus* and *Hypoplectrus* of the family *Serranidae*, the order *Perciformes* (ATZ, 1964). This condition is also possessed by one species, *Rivulus marmoratus* of the family *Cyprinodontidae*, the order *Microcyprini* (HARRINGTON, 1963).

In synchronous hermaphroditism, the mature fish completes simultaneously both oogenesis and spermatogenesis. Two lobes of the ovotestis are posteriorly fused, their cavities joining to form a com-
mon oviduct. A greater part of each lobe is occupied by ovarian lamellae, and a small part by testicular tissue. Although a common sperm duct opens independently to the exterior, self-fertilization as a possibility in synchronous hermaphrodites has been confirmed under laboratory conditions with *Rivulus marmoratus* (Harrington, 1963).

Functional hermaphroditism can also be seen in the protogynous and protoandrous forms. Among those belonging to the family *Serranidae*, the order *Perciformes*, all the groupers and their relatives, *Epinephelus, Mycteropecra, Alphestes, Petrometopon* and *Cephalopholis*, are protogynous. In the gonads of the protogynous species of the family *Serranidae*, ovarian lamellae fill the gonadal cavity during the female phase. In these lamellae, seminiferous crypts develop while the oocytes degenerate as the male phase supercedes the female (Smith, 1959). In one species, *Centropristes striatus*, the sex reversal from the female to the male was found to occur around the fifth year of life (Lavenda, 1949).

The synchronous hermaphroditism described above requires a special isolation mechanism which prevents androgenic hormones of testicular tissue from exerting a suppressing influence upon neighboring ovarian tissue. Thus, it cannot be regarded as a most primitive state of sex differentiation, yet, such a state surely reflects the total lack of chromosomal sex-determining factors. The protogynous and protoandrous types of functional hermaphroditism, on the other hand, may be regarded as most primitive because here sex-determination is the result of the aging process.

At any rate, the persistence of functional hermaphroditism into certain teleost fishes of today is one evidence that, within the genome of ancestral vertebrates (which emerged for the first time 300 million years ago) there was no particular chromosome which had accumulated enough sex-determining factors to be qualified as the sex chromosome.

b) The Absence of Cytologically Detectable Sex Chromosomes in Lower Vertebrates

Functional hermaphroditism occurs only in certain member species of the orders *Perciformes, Microcyprini, and Myctophiformes* among the teleost fishes. A great majority of the teleosts are gonochorists, individual members of the species being either males or