Canary Culture

Concepts in Genetics

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Red factor canaries

Figure 7

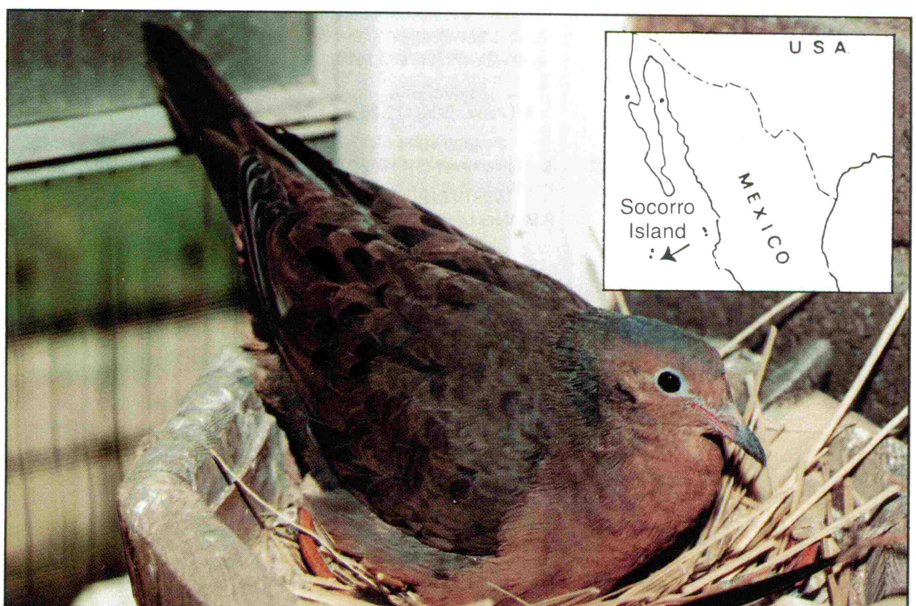
Photos by Tony Bucci

Warning! After reading this article, and the knowledge you gain from reading it, you will not be able to splice genes, or modify chromosomes to create a black canary. Instead, this article and subsequent articles on the same subject will give you rudimentary concepts of the subject genetics dealing with canaries. Canaries are mostly bred for show purposes, and breeders are striving to improve their conformation or color so it is important to be familiar with some concepts of genetics.

Genetics is a comparatively young science. It has been developed mostly during the present century, but it is interesting to go back to earlier studies to see how the background for modern genetics has evolved. Application of genetic principles in breeding and selection of cultivated plants and domestic animals date back to ancient records. For example, early Chinese accounts show that superior varieties

Parisian frill

Figure 6



of rice had been developed almost 6,000 years ago. Ancient Egyptian paintings depict pictures of man cross-pollinating the date palm. The great number of dogs and cats that exist today show that our distant ancestors were using genetic breeding techniques to produce animals best suited to their needs.

Genetics is the branch of biology that deals with the transfer of hereditary characteristics from one generation to the next. Throughout recorded history, the transmission of physical traits from parents to offspring has been recognized. The earliest recorded speculation about the nature of transmission of inherited characteristics comes from Greek philosophers; Pythagoras, Empedocles, and Aristotle.

Pythagoras, who lived about five centuries before Christ, proposed the concept that moist vapors descended from an animal's body during coitus, and that these form body parts in the embryo similar to the body parts from which they came.

Empedocles, another philosopher of the same period, proposed that each parent produced a semen in the various body parts and that these unite and form similar parts in the embryo. He suggested that not all of the semen from both parents is used and, hence, a child will show some characteristics of one parent and some of another while some characteristics of the parents will be lacking altogether.

Aristotle, some two hundred years later, modified this theory by suggesting that blood is the true element of heredity. This viewpoint carried great weight with scholars for many centuries, and even today there are some who feel that blood has a hereditary influence. We use the terms, "blood relative," "blood line," "new blood," evidence of how Aristotle's concept has influenced the thinking on inheritance.

It was only in the recent years the basic laws of heredity began to be understood. The seventeenth and eighteenth centuries proved to be fruitful years for the advancement of genetic concepts. A Dutch microscope-maker, Anton van Leeuwenhoek (1632-1723), saw living sperm in the semen of a number of different animals, including man. Still another Dutch scientist, Regnier de Graaf (1641-1673), studied the ovaries of different animals and found that the ovaries of mammals produce eggs just the same as ovaries of birds although the mammal eggs are much smaller. The German scientist, Kaspar Friedrich Wolff (1733-1794), made extensive studies of the development of the chick embryo. He proposed the theory of epigenesis which held that both male and female gametes (sperm and egg) contain bodies which, after fertilization, become organized into body organs. This is quite similar to our present concept of the genes as the basis of inheritance.

In the 1850s, the Austrian monk, Gregor Mendel, working in a monastery in Brun, succeeded to establish the basic laws of heredity. For investigation, he used the garden pea, in which it is possible to control pollination. Among the traits he observed were "round" versus "wrinkled" seed, "yellow" versus "green," "white" versus "brown" seed coats, "inflated" versus "constricted" seed pods, "green" versus "yellow" pods, and "long" versus "short" stems. For each of these "phenotypic" traits, a single plant can be classified as belonging to one or the other category.

In 1865, after eight years of investigation, Mendel presented his conclusions before the Science Research Society at Brun, Austria. The significance of Mendel's work was not immediately recognized and lay forgotten until 1900. In that year, Karl Erich Correus, Hugo de Vries, and Tschermak von Seysenegg, each working independently, arrived at conclusions similar to those of Mendel. They also discovered his paper and recognized its great importance. The year 1900 thus marks the beginning of genetics as a science.

To form a concept of the hereditary process, we will begin by understanding the make-up of the egg (ovum) and the sperm.

The Ovum (Female Gamete)

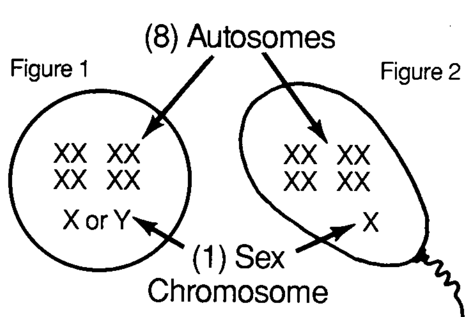
The ovum is the unfertilized egg. It is a sex cell and contains only one half of the ingredients which make up the mother hen. For example, the color of her feathers, her physical shape, etc. is stored in the ovum. If observed under a powerful microscope, within the nucleus of the ovum several particles can be seen. These particles are called "chromosomes," and it is within these chromosomes the genetic information of the hen is stored.

The ovum contains only half the chromosomes of a normal cell. The normal cell throughout the body of the canary contains 18 chromosomes each. In all multicellular plants and animals which have sexual reproduction there is a special kind of cell division, known as *meiosis,* which achieves a reduction in number of chromosomes within the cell to one half. The egg of the canary (before the fusion of gametes) contains eight chromosomes plus one X or one Y. The X and Y chromosomes are called "sex chromosomes." The remainder are autosomes (see Figure 1).

The Sperm (Male Gamete)

The sperm is the male sex cell. Like the ovum, it has gone through the process of cell division called meiosis. In most male animals, meiosis occurs in the testes, therefore, the sperm has also only eight chromosomes plus one X "sex chromosome" as opposed to the ovum which has one X or one Y sex chromosome. Here we can observe the difference between the birds and humans, where the human male sex cell has X or Y sex chromosome. Note that the egg and the sperm are referred to as "gametes" (Figure 2).

Figure 1 Figure 2

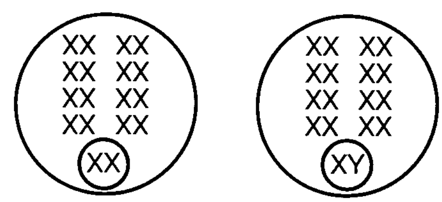


Egg Gamete **Sperm Gamete**

The Zygote

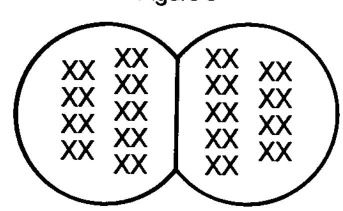
After successful copulation, the sperm cells will travel through the oviduct to meet the ovum (egg). One of the sperms may fuse with the ovum to form a *zygote.* Now, this single celled zygote, in essence, is a single celled canary, and has 18 chromosomes, 9 from the hen and 9 chromosomes from the cock. If the zygote has the combination of 16 autosomes plus the two (XX) sex chromosomes, then the canary will be a male (see Figure 3). To the contrary, if the zygote has the two (XY) sex chromosome combination, the canary will be a hen (see Figure 4). As soon as the ovum and the sperm unite, a process called *mitosis* begins. Mitosis is the process of cell division which will result in the production of two exactly the same as the original cell. Each new cell, consequently, has a full set of chromosomes pairs, identical with the original set possessed by the parent cell. This process continues in the descent of the egg through the oviduct and during the incubation. As the cell divides, each new cell contains

Figure 3 Figure 4



Male Zygote **Female Zygote**

Figure 5



Mitosis

identical genetic material (see Figure 5). This process continues, each cell dividing, until finally a baby chick is formed. Actually, this process never stops during the whole life of the canary. The blood forming cells of the bone marrow, the cells of the skin, intestinal lining, feathers and the cells forming reproductive gametes divide when need arises to replace the exhausted or damaged cells.

Phenotype

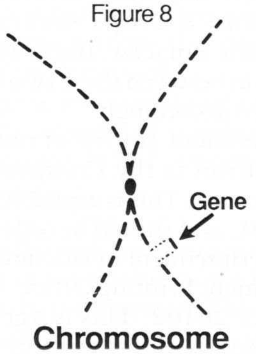
The many features by which we recognize a canary constitutes its *phenotype.* A Parisian frill, for example, possesses a combination of features by which we know it as a Parisian frill and thus distinguishes it from other canaries. Some of its "phenotypic" characteristics are its large size, the feather frilling on its head and body, and, in fact, the overall conformation of its body shape (see Figures 6 and 7). The two photographs are both of canaries, but there are certain phenotypic differences between them. Thus, phenotypes are the means of recognition of differences between canaries, just as Mendel recognized the phenotypic differences in peas.

Genotype

Numerous phenotypic traits, such as feather frilling, color, and size, appear to be transmitted from one generation to the next. However, offspring do not inherit phenotypes from their parents. Rather, they inherit the ability to produce these phenotypes. This ability resides in the "genotype" that is transmitted from one generation to the next.

The genotype is composed of numerous sub-units called *genes* which have specific chemical and physical properties that ultimately determine the nature of the phenotype.

Figure 8



Chromosomes and Genes

A chromosome is made up of a whole string of genes, each of which determines a different characteristic. One modern estimate is that each canary chromosome contains somewhat more than 3,000 genes. Genes determine such features as shape, size, song, color and sex of the canary. Genes make up orderly units of the thread-like chromosome (see Figure 8). Each gene occupies a specific place on a certain chromosome. Genes are primarily made up of *deoxyribonucleic acid* (DNA).

This concludes Part I of this article. Part II will follow in the next issue. ●

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