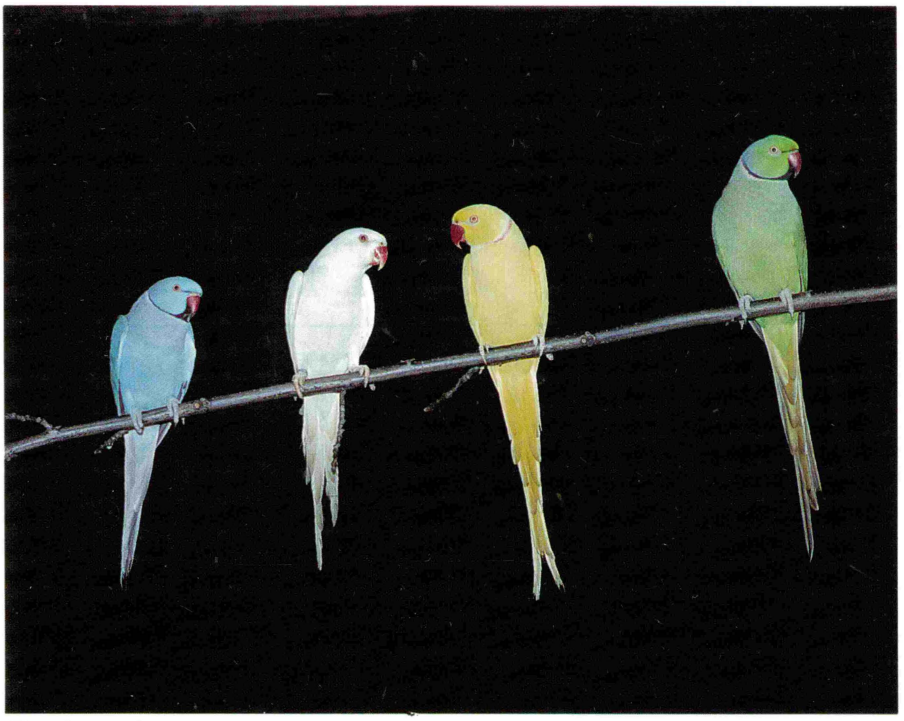
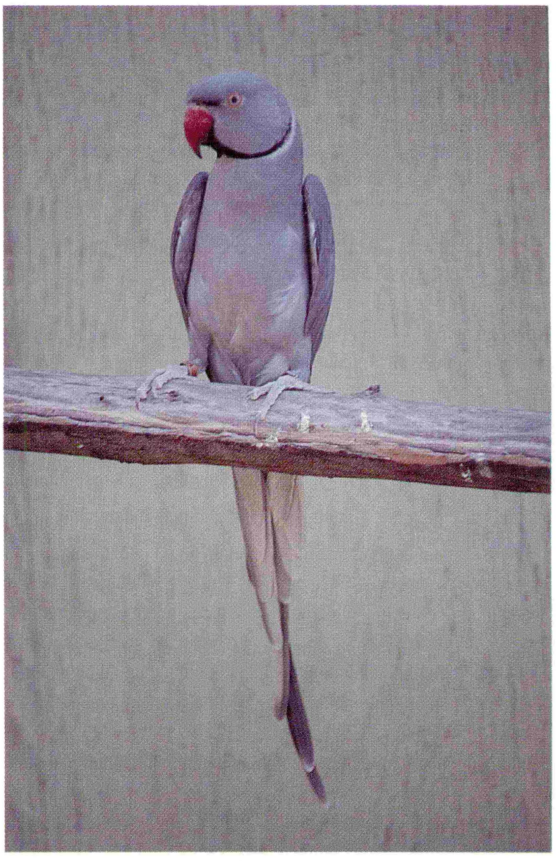
Photos by Jaynee Salan

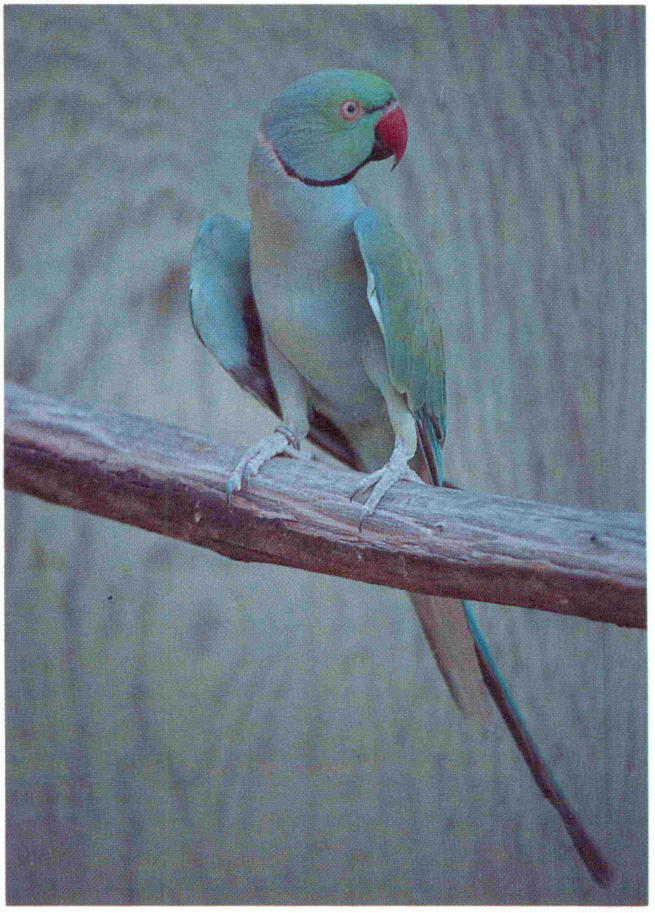


This classic photo depicts normal green, blue, lutino, and albino mutations, four of the earliest colors. Jaynee Salan took the photo in the aviary of Rae Anderson in 1976.



Ring-necked Parakeet, the grey mutation.

Two male pieds, green and blue.



The turquoise mutation of the Ringneck.

Microevolution of a Mutation

by Jaynee Salan, Lake Arrowhead, CA

Charles Darwin wrote in his diary, "both in space and time, we seem to be brought somewhat near to that great fact - that mystery of mysteries - the first appearance of new beings on this Earth." The beginning of species is at the focal point of evolutionary theory, for it is in new species that biological diversity arises.

Diversity is a hallmark of life. Biological diversity is something to relish and preserve, but it can also be a bit overwhelming. SELECTIVE REPRODUCTION is what Charles Darwin called NATURAL SELECTION and he envisioned it as the cause for evolution. Life comes from life, an axiom known as "BIOSYNTHESIS."

In some ways, biology is the most demanding of all sciences, partly because living systems are so complex. Modern biology is the decathlon of science. Biologists have identified and named about 1.7 million species, including 400,000 plants, almost 40,000 vertebrates (animals with a backbone) and more than 750,000 insects; thousands of newly identified species are added to the list each year.

As nature progresses, it does so in one of two ways; either by inspiration or desperation. Nature can move forward, which is known as NATURAL SELECTION, or nature can stand still, known as ARTIFICIAL SELECTION and extinction will eventually occur. The biochemical basis and understanding for each of these diametrically opposed phenomena is the subject of a great deal of confusion, misrepresentation and wonder. The results of each of these natural occurrences differ dramatically.

Hybridization, or ARTIFICIAL SELECTION, does occur in nature under adverse conditions. Birds spend 85% of their waking hours in pursuit of food or in pursuit of a suitable mate. When a bird wanders out of its range in pursuit of either of these two life sustaining items, hybrids can occur. When a population is geographically separated, it is known as "ALLOPATRIC." When their ranges overlap, it is known as "SYMPATRIC."

Even if two distinct species mate and produce hybrid youngsters that are vigorous, the hybrids are very likely sterile because genes cannot flow from one species' gene pool to the other. One cause of this barrier is a failure of meiosis (a special kind of embryonic cell division) to produce normal gametes (sex cells) in the hybrid if the chromosomes of the two parent species differ in number or structure. In some cases when species cross-mate and the first generation would be viable and fertile, in the succeeding generation when the hybrids mate or they are paired with either of their parents, the next generation of hybrids will be feeble or sterile or can be both. This is the pathway that eventually leads to extinction.

It is estimated that once a viable hybrid parrot has been created, the attempts to purify the original biochemical structure of the species will take at least seven generations to return the chromosomal structure to it's near original, viable state.

A case in point of possible hybridization caused by artificial selection is that of the single Spix's Macaw which is the only known member of his species in the wild. Out of desparation he has mated with a female Iliger's Macaw and they seem to have produced a clutch of eggs. The eggs were old when the field biologists found them, one contained an embryo that died at about 10-11 days, and the other two were clear. As I write this article, DNA work is being done to determine if the egg was fertilized by the Spix's Macaw or whether the hen slipped off and mated with a local Iliger's male.

Another phenomenon within the realm of BIOSYNTHESIS is NATURAL SELECTION, ALSO KNOWN AS MICROEVOLUTION. There are five potential agents of microevolution: genetic drift, gene flow, mutation pressure, assortive mating and natural selection. MUTATIONS ARE THE EXCLUSIVE SOURCE OF NEW GENES and experts estimate that a mutation appears spontaneously about 1/10th of 1%, thus evolutionary genetic recombination.

As mutations occur in nature, they are the programmed product of genes that are transmitted by orderly mechanisms and subject to modification. The aspect of genes and their capacity for change is an important link between genetics and evolution.

The most cited and extensively documented example of natural selection/mutations involves the English Peppered Moth (*Biston vetularia*). It is found throughout the English countryside. It occurs in two varieties of different colors. The color for which the peppered moth is named is light, with splotches of color pigment. The other color is pretty uniformly dark. Peppered moths feed at night and rest during the day on trees and rocks encrusted with lichens. Lichens often resemble mosses or other simple plants growing on rocks, tree trunks, the sides of buildings and other surfaces. Light colored moths can easily camouflage themselves, leaving the dark moths looking very conspicuous and easy prey for birds.

Prior to the Industrial Revolution, dark Peppered Moths were very rare, probably because they were bird food before they could pass their genes on to the next generation.

As the industrial pollution in England darkened the foliage in the 1800s, light moths stood out against the dark background of soot covered trees and rocks and dark moths were then concealed. The frequency of dark moths began to increase.

By the turn of the century the population in the Manchester, England region consisted almost entirely of dark moths. This phenomenon occurred in hundreds of other species of moths in polluted areas. The environment merely created a favorable

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setting for inherited variations to evolve, favoring the survival and reproduction of some individuals over others. Evolution is occurring on the smallest scale when the relative frequencies of alleles (alternative forms of a gene) in a population change over a succession of generations; such change in a gene pool is call MICROEVOLUTION.

The exquisite color adaptation (the products of NATURAL SELECTION, i.e., mutations), and in particular, the Indian Ring-necked Parakeet Pied mutation is the subject of this paper.

I have had the distinct joy to work with and watch these Ringnecks evolve in an array of variegated colors known as POLYGENIC INHERITANCE over the last 25 years. I wouldn't have changed any of this journey, either. They say that we don't find a mutation, it finds us!

Clearly, regulation of gene expression is a major key to development and discovering the genetic underpinnings for this dramatic transformation. This is a major challenge of biology today. Genetic information is expressed by its translation into proteins of specific structure and function which in turn brings about an organisms phenotype (the expressed traits). Since determining how genes are translated into proteins in the 1960s, scientists can give a description of inheritable changes that arise.

The DNA (deoxyribonucleic acid) inherited by an organism controls the activities of each cell by specifying the synthesis of enzymes and other proteins. A gene does not build a protein directly but instead dispatches instructions in the form of RNA (ribonucleic acid) which, in turn, programs protein synthesis which is governed by a chain of command; DNA - RNA - PROTEIN. This scheme is known as the "Central Dogma of Molecular Biology," a term coined by Francis Crick.

The Developmental Process

Very early in the embryonic development a process called GASTRULATION gives rise to the very first large scale cell movement. Prior to this stage there is just a hollow ball of proliferating cells. When cells begin to specialize with GASTRULATION they become committed to a position within the developing embryo. Measuring position through chemical signals creates grated signals.

John Gurdin, a British scientist, conducted a series of experiments with frogs in the 1960s. He took fully specialized (committed) intestinal cells from a white tadpole, broke open the nucleus of the cell and inserted that package of instructional genes into a Green Frogs fertilized egg whose own nucleus had been killed. The Green Frog's egg now had the nucleus, the instructional genes of a white tadpole's intestinal cells. It should be able to instruct the embryo to become a white tadpole rather than a green tadpole.

The experiment was done hundreds of times and in a few cases it worked. Gurdin proved that one cell in the body could carry the genetic blueprint for the entire animal.

The avian organism consists of thousands of individual genes, each of which serves a function. The genes are arrayed along pairs of chromosomes. Ninety-five percent of the genes are known as housekeeping genes; they eat, breathe, metabolize and do everyday things.

Master control genes (homeotic genes) comprise the other five percent. These central regulatory switches organize cells into patterns that make up tissue and their far reaching effects tell cells where to go and what to become within the developing organism. We look at master control genes as programming chips, setting the genetic programs and turning on banks of lower genes and coordinating their activity. A "cascade of gene expression," multiplied over many cells determines what kind of tissue will form. If that gene is mutated, a different cascade takes place. A tiny change in this master control gene completely alters the body pattern of the bird and transforms the body tissue.

In the case of our Grey-Green Pieds, there is a reduction and partial blockage of melanin deposit meaning that the color green is composed of blue and yellow. When the genes are mutated, the bird appears pure yellow in some areas of its body where there is no melanin being deposited and in other areas there is. The green appears with grey undertones. Lutino birds are manifested from a complete blockage of melanin deposit. Blue birds result from blockage of the capacity of the conversion of carotenoids or lipochromes. Our pied is a chromosomal mutation that occurs in the embryonic stages of development and the eventual pattern remains the entire life of the bird. Our Grey-Green Pieds do not lose any color markings, but only become more beautiful as they mature.

Homeotic Genes

Master control genes not only control spacial patterning, but also control timing. That is, genes which control particular aspects of the timing of development and body patterns are called "HOMEOTIC GENES."

Homeotic genes, genes that control the overall body plan of an animal are currently receiving a lot of attention in the field of research regarding the regulation of development. Homeotic gene sequences have also been identified in insects, crustaceans, fruit flies (*Drosophila*), annelids (microscopic worms), amphibians and mammals. These are animals with a body plan containing repeated segments of genes, significant in the formation of the segmented pattern and in the developmental determination of each of the body segments.

The Legacy

I have never been more proud to be an American aviculturist than on that particular day in May, 1983, when the grey-green pied ringneck appeared for the first time in the nest. I had finally received my breakthrough after 12 years of research. As I took the nestbox off the wall and sat it in the sun on the floor for a better look, a shiver went up my spine and tears welled up in my eyes. Any breeder who has ever had this happen knows the feeling is impossible to describe. Equally memorable was the occasion in San Francisco in 1985, at the AFA Convention, where I was recognized for my work with an AVY Award for achievement of the development of this mutation.

This pied mutation is astonishingly striking in a visual sense. This is a simple recessive, blue-eyed bird. Science literature refers to blue eyes in birds as a trait indicating recessive genes (red eyes or plum colored eyes in birds are almost always indicative of sex-linked traits). Probably the most remarkable feature of this pied is that males never acquire a mustachial ring. It is absent forever. Even our oldest adult males have never acquired a ring. Chromosomal mutations affect many loci and are usually inherited together as a package. A loci is merely one of many locations on a chromosome strand where a given gene is located and can mutate, affecting a physical trait somewhere on the bird's body.

In 1971 we had produced two youngsters that had large, pure yellow spots on the backs of their heads and pure yellow spots about the size of a nickel on the napes of their necks. These youngsters came from normal green parents. The mother we acquired at five days of age from a lovely, elderly lady who didn't know what to do with it and the father was purchased, at a premium price, from a mall here in southern California. We were told that he had been shipped in from somewhere in the midwest.

From that humble beginning in the early 1970s and with a lot of patience and wonderment through the years, we now have developed the genetic footprints of how this series of pieds have evolved.

To date, the Grey-Green Pied is flourishing and completely stable, meaning that we will not lose this beautiful color or pattern. The first world-wide breeding of the Blue-Violet-Grey-White Pied was hatched in our aviaries in 1990 and has been established. The first Grey Pied, the first Turquoise Pied and now, just two years ago, the first Violet Pied have been bred here in our aviaries.

I feel privledged to have had some of nature's most wonderful secrets unfold for us.

Through NATURAL SELECTION with modification, of which Charles Darwin spoke with such immaculate logic and an avalanche of evidence, he envisioned this as the cause for evolution. Today biologists are beginning to unravel some of nature's most engaging mysteries.