

# COLOR IN VARIOUS PLANT STRUCTURES AND THE SO-CALLED PRINCIPLE OF SELECTIVE ADAPTATION.

STUDIES IN DETERMINATE EVOLUTION, VII.\*

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In the lowest, living vascular plants there is usually very little color aside from the general green of the chlorophyll. This applies to the ferns, the flowerless clubmosses, and even to the lower, flower-bearing clubmosses and horsetails. In the higher clubmosses the cones sometimes become yellow and the highest horsetails have their fertile shoots and cones destitute of the green color of the sterile shoots. As one progresses upward through the flower series to the higher plants, more color is evolved and usually not only a greater diversity of tints in the various species, but also a much more complicated color chemistry in the individual petals and other parts, distributed in spots, dots, stripes, blotches, etc. This is because the higher plants as a general rule develop a more and more complex system of hereditary potentialities which come into play with the complex physiological gradients and states initiated in the developing inflorescence, flowers, and fruits and also in the purely vegetative parts.

In the general evolution of the flower, the movement is continually toward a more prompt determination of the floral axis, which commonly results in very small flowers as the final condition. In the more extreme reductions there is thus a strong tendency to eliminate the color because the corolla or even the entire perianth is lost. Thus in both bisporangiate and monosporangiate species the flower clusters are often almost destitute of color. The crowding of small flowers in the higher types of inflorescences may, however, compensate for this reduction movement and the color display may also appear farther down the axis, even in the leaves below the inflorescence. Sometimes then in monosporangiate inflorescences there are prominent displays of color even though the individual units

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are inconspicuous. In such species as *Populus deltoides* Marsh. the staminate catkins are a very conspicuous purple-red because of the red anthers, but the carpellate catkins are inconspicuous because of the pale green color of the ovularies. In some of the intermediate types of flowers like many of the pines, larches, firs, and spruces, the color display is very conspicuous, both because of the intensity of the color itself and because of the size of the cones. Many of the wind pollinated gymnosperms have very conspicuous and showy strobili, both staminate and carpellate, as for example, *Picea abies* (L.) Karst. Some are also very fragrant, like the staminate cones of *Dioon edule* Lindl. Of course, it would be quite ridiculous to claim that the color was to attract the wind, but not more so than to claim that specific colors were evolved to attract insects when we know that the ordinary insects, like the wind, may visit a great diversity of colors even in a single nectar-foraging expedition.

It is interesting to note that teleologists in their zeal to expound and prove the causal relation between color of flowers and insects have almost entirely lost sight of the great host of beautifully colored anemophilous flowers. A very extensive teleological literature on the color and form of flowers and on color patterns in general has been developed in the past hundred and forty years. In 1793 Christian Conrad Sprengel published his treatise on the structure of flowers with special reference to the aid of insects in their pollination. Sprengel said that, "Nature seems to have wished that no flower should be fertilized by its own pollen." This superficial notion became generally accepted after the publication of Darwin's book on the fertilization of orchids by insects, which appeared in 1862, and by papers published by Hermann Mueller in 1873 on pollination of flowers through the aid of insects. Darwin stated that "Nature abhors perpetual self-fertilization." Since for the next twenty-five years natural selection was generally assumed to be the causative agent in evolution, the color of flowers and fruits and color patterns in general furnished themes for whole libraries of books and papers on the subject.

As stated, during the years of rampant speculations of the neodarwinian teleology, one of the most universally exploited phenomena of the flowering plants was the prominent display in these plants of the color of flowers and fruits. All the diverse colors and endless patterns of streaks, lines, spots, dots, dashes, and nets were explained as being the result of a life and death

selecting action by insects and other animals which fed on the pollen, nectar, and fruits. Each spot was a recognition mark, each streak a line to guide the hungry or thirst insect to the proffered stores. Every fantastic pattern was of life and death utility to the possessor and had been acquired through "natural selection" because of its survival value to the individual. The most remarkable phenomenon in this enthusiastic pursuit of pseudo-science was that its devotees never seemed to see the conspicuous and attractive colors in flowers that were visited only by the wind, never seemed to discover the bright colored lines and splotches so common on the stems and leaves of many weeds, whose flowers are not even noticed by insects, never speculated on the attractive value of the underground color of roots. The natural selection delusion followed the same course as have other delusions. The fantastic, teleological explanations exceeded anything ever imagined by the inventors of fairy stories to account for unsolved phenomena of nature. One could write volumes on the absurdities alone which have been perpetuated since the beginning of the twentieth century when De Vries with his mutation theory introduced a wholesome check, which should have brought to an end this unscientific era of "science." But though the teleological citidels of neo-lamarckism and neo-darwinism were badly battered by the mutation theory and the rediscovery of Mendelian heredity, the teleologist defenders did not surrender their beliefs but continue powerful in all lines of speculative philosophy and science up to the present time.

Especially preposterous are some of the Lamarckian explanations in some present textbooks of geology. Birds are said to have originated as follows: "These more active running and bipedal pro-avian lizards probably had their entire body covered with over-lapping scales, and jumping about from branch to branch or tree to tree, learned not only to parachute, but eventually to flop their front limbs in aviation. In these efforts the scales changed into long and complicated fronds and finally became feathers that maintained the body warmth," etc. "In the fishes, the paired fins with their girdles are the rudiments out of which legs and feet were developed through the enforced hobbling of the fringe-finned ganoids in their search for water holes in desert regions." Fishes got lungs in this way. "It is thought that under the stimulus of these changes gill-breathing fishes first adapted themselves to bur-

rowing in the sand. Thus protected in water and mud holes there was for a time moisture to pass over the gills, but under such environments life was very precarious and in the struggle most of the individuals were destroyed. After innumerable failures in their efforts to gulp the air into the pharynx, efforts lasting through long geologic time, the ganoids and lung fishes were gradually developed and perfected." It is difficult to imagine how credulity could invent anything more absurd than these statements.

In present university textbooks of botany, one can read that "butterfly flowers are frequently red, bee-flowers blue or purple." One need only watch a swarm of bees or bumble-bees at work to promptly discover that they exercise no such color preferences. The deductions are the result of philosophical belief rather than accurate observation. I have seen individual bees gathering nectar from flowers of almost every color of the rainbow in the space of a few minutes. The following is a dissertation on "honey-guides:" "In numerous flowers the entrance by which nectar is approached is marked by a ring or flush, colored differently from the rest of the flower, or lines and streaks converge upon it." Of course, one can find such rings and flushes or converging lines in all sorts of plant structures where no nectar is available for the unlucky insect that might be allured by such "guides."

The following is a sample of the popular science of a dozen years ago by a popular writer on nature themes. It is not one particle more ridiculous than what commonly appeared in the standard treatises put out by those who were considered leaders in the realm of scientific thought. "*The dandelion head.* Half the involucre bends downwards to protect the flower from crawling pilferers, half stands erect to play the role for the community of florets within that the calyx does for individual blossoms. Seated on a fleshy receptacle, not one flower, but often two hundred minute, perfect florets generously co-operate. In union there is strength. . . . Each floret of itself could hope for no attention from busy insects; united, how gorgeously attractive their disks of overlapping rays are! . . . Each floret insures cross-pollination from insects crawling over the head, much as the minute yellow tubes in the center of a daisy do. Quantities of small bees, wasps, flies, butterflies, and beetles—over a hundred species of insects—come seeking the nectar that wells up in each little tube and the abundant

pollen, which are greatly appreciated in early spring when food is scarce." Now it will be evident how ridiculous this teleological description is when it is known that our common dandelion is parthenogenetic, the eggs developing new plants without fertilization, and that neither the pollen nor the insects which spread it about are of any use whatever to the plant in its present condition. It has evolved into a highly efficient parthenogenetic species in direct contradiction to the supposed causative selection, produced by insects and its allurements of color and nectar.

Special colors may be present in all parts of plants and its development is due to the evolution of potentialities producing certain chemical reactions or diffraction surfaces which have no relation to survival of the species as the following examples will indicate:

*Color of Pollen.*—Pollen grains are of many colors. Sometimes they are of the same color as the anthers in which they are contained; sometimes they are of an entirely different color; sometimes the color corresponds with that of the petals, and sometimes it is of an entirely different tint. How foolish to think that the insect, after it had been attracted to the flower, would refuse to gather nectar or the pollen because it happened to be of a different tint from the petals or anthers. The colors of the pollen are as diverse as those of the rainbow. *Koellia incana* (L.) Ktz. has purple anthers and pure white pollen. *Staphylea trifolia* L. has yellow pollen and white petals. *Aesculus glabra* Willd. has orange pollen. *Iris-regelio-cyclas* hybrids (varieties Psyche, Parthenope, Luna, and Hebe) have green pollen. *Saponaria ocymoides* L. has bright blue pollen in blue anthers with a pink corolla as a background. *Geranium sanguineum* L. has blue pollen. *Echium vulgare* L. has light blue pollen. *Lilium pardalinum* Kell. and some other species of *Lilium* have red anthers and red pollen. *Aesculus hippocastanum* L. has pinkish red pollen. *Dianthus carthusianorum* L. has blue pollen and a dark red corolla. *Claytonia virginica* L. has white pollen in pink anthers. *Sedum ternatum* Mx. has pure white pollen in purple anthers. *Impatiens sultana* Hook. f. has pure violet-purple pollen. *Ipomoea purpurea* (L.) Lam. has pure white pollen. *Iris halophila* Pall. has bright orange pollen. *Leontodon taraxacum* L. has yellow pollen and a yellow corolla. *Lilium longiflorum* Thunb. has bright yellow pollen and white petals. *Linum usitatissimum* L. has white pollen

and a blue corolla. *Papaver orientale* L. has dark purple pollen in anthers of the same color and red petals. *Geranium maculatum* L. has light yellow pollen and light purple petals.

Some plants have pollen in two colors. In *Commelina communis* L. the two, upper, outer stamens have dull whitish pollen while the odd, upper, inner stamen has orange yellow pollen. These differences are caused by the zygomorphic condition and the advanced complexity of hereditary color factors as compared with its near relatives which have pollen of only one color, although the flower as a whole may have just as great a complexity of color potentialities. The duality of pollen color is dependent on the zygomorphic gradients developed in the determinate growth of the flower and not on any advantage or disadvantage to the species.

Why do plants have pollen of such diverse colors? For the same reason that corollas and other parts have such colors, but it is not to attract insects, nor for any other imaginary teleological purpose, but just as in the case of inorganic salts and rocks, so the various parts of living things show a great diversity of colors and color patterns as a part of the universal design of nature.

*Color and Texture of Roots.*—The parts of a plant that are continually underground are often as brightly colored as those exposed to the light of day and there is also a wide range of tints. In *Equisetum kansanum* Schaffn. and other species the rhizomes are pure black. *Physalis lanceolata* Mx. and *Xanthium pennsylvanicum* Wallr. have pure white roots. *Psoralea floribunda* Nutt. has light-brown roots. In *Toxylon pomiferum* Raf. the roots are orange in color. *Parosela enneandra* (Nutt.) Britt. has lemon-yellow roots. *Morus alba* L. has yellow-orange roots. *Celastrus scandens* L. has bright orange-red roots. *Amaranthus retroflexus* L. has pink roots. *Sansevieria thyrsoiflora* Thunb., a common greenhouse species, has bright orange rhizomes and roots. Nearly all of these species, except *Sansevieria*, grow and are eminently successful in dry prairie soils where there are no essential physical differences. So a selectionist will have to fall back on biological factors to account for the differences and in a sarcastic mood it might be suggested that the black rhizomes of *Equisetum* are a protective coloration adaptation against the ravages of earthworms and gophers, and those roots with bright colors have an attractive value for the denizens of the underground realms of darkness.

Now the same general conditions and discrepancies in respect to color and environment exist above ground, but the enthusiastic, teleological selectionists apparently never saw the misfits. They had eyes adjusted only according to their teleological or utilitarian faith.

In the same prairie soil the texture of roots also shows that there is no teleological adaptation, no "selective adjustment." All such theorizing is not based on any sound philosophic or scientific principle. It is of the same sort as any witch doctor employs. The supposed process or supposed fact of increasing adaptation is even assumed to be a novel manifestation in the universe, but the supposed "principle of selective adaptation" is not at all true and comes from a lack of a broad knowledge of living things and their phyletic relationships. Bacteria are adapted to survive and thrive through the geological ages as well as dandelions. Amoebas are just as well adapted as men. The fitness of their "adaptation" has nothing to do with their real taxonomic differences.

Returning to the characteristics of roots, we find that their textures are as extremely diverse in the same soil environment as are their colors. A few of the typical dry prairie roots are as follows: *Amorpha canescens* Pursh has exceedingly strong, tough roots. *Morongia uncinata* (Willd.) Britt. has such very brittle roots that they break as readily as sticks of candy. These two deep-rooted plants are often seen growing in the same prairie soil within a foot of each other. To speak of the toughness and brittleness as "adaptations" or the survivals of a "selective adaptation" is the height of foolishness. Other roots have all sorts and conditions of texture in the same soil. There are also all sorts of flavors in these roots. Sometimes very odd "adaptations" are encountered, as in *Equisetum palustre* L., which usually grows in wet soil. It has elastic rhizomes that can be stretched to a considerable extent like rubber. This "adaptation" might be of decided advantage and use in case of an earthquake or landslide! *Raphanus sativus* L. of our gardens has a thick, crisp, fleshy root. The rhizome of *Distichlis spicata* (L.) Greene is hard and rigid not because it grows in saline or alkaline soil, since the same type of rhizome may be found in soils of entirely different character, but simply because such "adaptations" are of no importance to the plant. It could thrive in the same habitat if it had an

entirely different "adaptation." It might be brittle or fleshy for example.

*Variouly Colored Twigs.*—The color of twigs runs through about the same series as that of the roots. One can find almost any general color desired and there are also many ornamental patterns of streaks, blotches, mottlings and speckles. *Euonymus atropurpureus* Jacq. has green twigs. *Cornus stolonifera* Mx. has bright reddish-purple twigs. *Salix lucida* Muhl. has yellowish-brown twigs. *Ulmus americana* L. has brown twigs. In *Cercis canadensis* L. the twigs are dark reddish-brown and speckled. In *Gymnocladus dioica* (L.) Koch. the twigs are mottled white and purplish-brown. In *Amygdalus persica* L. the twigs are red above and green beneath. *Fraxinus americana* L. has dark gray twigs. The twigs of some woody plants and the stems of many herbaceous plants with inconspicuous flowers are striped. *Acer pennsylvanicum* L. has green twigs striped with darker lines. As a general rule the color of twigs is less brilliant than that of roots. This is probably due largely to the difference in the character of the epidermis and cuticle as commonly developed in the two systems. As in the case of the colored roots, to attempt to give a utilitarian explanation to the diversity of color tints of twigs would be extremely irrational, because no such utility is in evidence. These woody twigs grow in the same air and light and are subject to the same heat and cold, to the same dryness and moisture. Leaves have a more pronounced development of color and color patterns, with spots, streaks, and mottlings, than do roots or twigs, and those markings again can have no special utilitarian import. Only a mind of the most extreme credulity or perverted philosophic outlook could conceive of such a relationship.

*Color of Plant Juices.*—In many plants there are distinctive saps and juices of various chemical composition and these, as would be expected, are also of various colors. Very commonly the juice is colorless although it may have various chemical compounds. *Dicrophyllum marginatum* (Pursh) K. & G. and an endless array of species, genera, and families of plants have white juice, commonly called milky sap or juice. *Chelidonium majus* L. has saffron-colored juice. *Argemone intermedia* Sw. has bright yellow juice. *Sanguinaria canadensis* L. has red-orange juice. *Amorpha canescens* Pursh has bright coral-red juice, which is especially abundant in the young herbaceous

shoots before they become woody. Some species of *Boletus*, a genus of the Agaricales, have a juice which develops a clear blue color when the plant is broken. To claim that the yellow color of surplur, the white color of common salt, the blue color of sulphate of copper, and the green color of sulphate of iron are caused by "selective adaptation" would be rather foolish; to think that the colors of these plant juices must in some way be the result of "the selective adaptation principle" is equally so and the same observation applies to specific colors on the outside of the plant or animal. But the realms of fancy are infinite and the credulity of natural selectionists is boundless.

Any one studying the taxonomic system carefully will soon find that there is no general correspondence between the system on which we postulate relationships of groups and the so-called adaptations. There are adaptations to various conditions, as to cold, light, dryness, moisture, water, etc., but these do not run parallel with the taxonomic characters. They have little to do with the real fundamental problem of evolution. There is still no evidence whatever for the inheritance of characters acquired through response to environment and even if there were it would be of little consequence in the real problem of evolution. Since there is no direct correspondence between the environment and the taxonomic segregations and series, the hypothesis of either selective adaptation or of adaptation as a response of the individual to the environment is not tenable as an evolutionary causative agent or principle, but is rather the product of minds blindly reacting to an anarchistic belief as to the nature of the universe about us.

Recently, confusion has been introduced between the ideas of "natural selection" and selective elimination. We may have selective elimination whenever an evolutionary movement is proceeding in the presence of an exceedingly adverse environment, but usually the broader more fundamental taxonomic movements are not of such a nature as to produce an eliminative struggle. A lycopod without flowers succeeds in the same environment as one with flowers. A composite with the flowers in heads is just as much adapted to a dry prairie condition and no more so than a legume whose flowers are in a raceme. The epigynous composites or evening-primroses are no better fitted for a dry prairie environment than are hypogynous anemones and poppy-mallows. They all grow side by side. The special "adaptations" are the result of

internal causes as well as are the more fundamental characters which make up the taxonomic system. The "adaptations" are sometimes of use to the individual, but just as frequently they are of no use whatever or they may even be a decided detriment. The evolution proceeds in a given direction not because the environment is producing the change, but because the environment permits the orthogenetic movement to proceed in the given direction. The so-called "principle of selective adaptation" is a delusion, a figment of the imagination, and is contradicted by all the more fundamental evolutionary sequences plainly indicated in any study of the taxonomic system in relation to the environment.

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#### The Action of the Living Cell.

Dr. Fenton B. Turck, whose death occurred a few months before the publication of this book, was a well-known surgeon in Chicago and New York. Over a long period of years he made many contributions to medical literature, many of them being concerned with the problem of surgical shock. As a result of this work he developed his theory of a *cytost*, or shock-toxin, a substance supposedly liberated from cells after their injury or death, affecting the activities of other cells of the body, and, if in sufficient amount, directly or indirectly causing the characteristic symptoms of traumatic shock. In his later years, Dr. Turck carried on considerable experimental work, first in the effort to test his theory, and later with the aim of learning more about *cytost* and its mode of action. The present book is not only a re-statement of the *cytost* theory and an account of the author's observations and experiments, but represents also an attempt to interpret these in terms of general cell physiology.

It is only fair to say that the majority of surgeons still regard the *cytost* theory as unproven. A considerable amount of experimental work by a number of competent investigators seems to indicate that the loss of blood and fluid from the body tissues, which in general accompanies or follows traumatic injury, is not a secondary effect, but is the primary cause of traumatic shock. If these results are substantiated, it will obviously not be necessary to postulate a special shock-toxin to account for most shock phenomena. However, many of Dr. Turck's later experimental results, as described in the present volume, are definitely irreconcilable with this alternative interpretation. The general concept of a cell-product stimulating or depressing the activities of other cells is, of course, firmly established today as a physiological principle. A few investigators, working independently, have also found some evidence (in Bacteria and Protozoa) for a depressing effect exerted upon living cells by products formed through the death and disintegration of other cells. In view of these facts, it is to be hoped that Dr. Turck's later experiments will be carefully repeated in detail by other investigators, and that this important field will be thoroughly explored.

W. J. KOSTIR.

**The Action of the Living Cell.** Experimental Researches in Biology. By Fenton B. Turck. xi+308 pp. New York, The Macmillan Company, 1933. \$3.50.