Essays in Philosophical Zoology by Adolf Portmann

The Living Form and the Seeing Eye

Translated, with an Interpretive Essay by
Richard B. Carter

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CONTENTS

Preface i

Acknowledgements v

Translator's Introduction vii

Part I
The Living Being as an Other-Inclusive Self 1

Chapter I
The Orientation and World-Relation of Animals: New Results of Biological Research 3

Chapter II
The Living Thing as a Pre-Arranged Relationship 21

Part II
The Expanded Science of Living Beings 45

Chapter III
Problem of Living Things 47

Chapter IV
Contemporary Biological Research 79

Part III
Peculiarities of Human Evolution 95

Chapter V
The Path Leading to Words: Levels of Living Communication 97

Chapter VI
Human Beings in the Perspective of the Theory of Evolution 125

Part IV
The Living Form-Construct 145

Chapter VII
What Does the Living Form Mean to Us? 147

Chapter VIII
Goethe and the Concept of Metamorphosis 161

Appendix IV

J. W. Goethe's

Versuch Die Metamorphose Der Pflanzen Zu Erklären
(An Attempt to Explain the Metamorphosis of Plants)

Introduction to the Translation 179

Translation by Agnes Arber 207

Translator's Essay 257

Index 277

PREFACE

REVERENCE IN THE PRESENCE OF LIVING THINGS

On the Death of Adolf Portmann

In losing Adolf Portmann, formerly the Professor of Zoology at Basel University, the world doubtlessly lost one of the greatest and, at the same time, one of the most controversial biologists of our time. And controversial he was! For, he accepted the presently popular thesis of evolutionary theory only with definite reservations. He utterly rejected the extreme version of reductionism which teaches that all phenomena involving living things can be reduced finally to physics and chemistry. These living phenomena continuously presented Portmann with "the familiar mystery of living things," and he found this familiar mystery at every turn. Indeed, that is the title of the detailed Portmann biography which the Max-Planc Institute biologist, Joachim Illies, gave to his book concerning Adolf Portmann's life and work. (It is a tragic coincidence that Illies died a few weeks before Portmann.

But Portmann went further than merely to reject reductionism; he also rejected the modern theory according to which all developed living beings are the coincidental shells -- so to speak, the litter -- of their selfish genes. Precisely, that "total visual picture," or "gestalt" of the organism had captivated Portmann during his whole life, and he devoted his most widely known book to the question of the animal's gestalt. He confessed in the Foreword to that book, (*Die Tiergestalt*), that he who had originally wanted to be an artist had written the book out of the joy he had taken in his

observations of the total visual picture of animals. He did not carry on his researches only with the eyes of the stone cold sober zoologist, but also, and at the same time, with the eyes of an artist, with uncompromising intensity and with deep reverence for the familiar mystery of life. "For only he who knows the immediately and easily accessible things also suspects the extent of the hidden things." Such beliefs, and his concept of "inwardness" led to his expulsion "from the club made up of the ruling caste of science," (Illies). He was also looked upon as a renegade because he held that mutation and selection could not be the sole design engineers of species-modification. In spite of this, he received a great many national and international honors.

Portmann recognized absolutely no dogmas -- either biological, religious, or political. He himself built his own world view on the foundation of a profound comprehension and awareness of form which is concerned with the world of marine animals and with that in it which is so often lacking today because the consideration of complete animals has been pushed into the background through the analysis of the individual cells and cell-parts.

The division between research and teaching posed no problem in Portmann's case. He performed both passionately. His lectures, courses, and reports were lively and exciting and he often relaxed their tension through humor -- as I know from personal experience which began in my first semester and extended to the last -- and even beyond to my lectureship and on to my assistantship. Our friendship thus developed over a 25 year period.

Portmann's Saturday lectures finally became such a legendary event that they had to be located in a very large lecture hall outside the Zoological Institute. In this somewhat extra-territorial space, Portmann dealt with themes which had hitherto been more or less peripheral -- as, for example, with peculiar aspects of rabies with its contradictory symptoms of thirst and fear of water or hydrophobia, themes which permitted something of the evil of nature to glimmer through to our vision. At other times, he broke open the walls surrounding zoology and dealt with issues which were highly exciting for physicians, anthropologists, psychologists, philosophers and even for theologians. One only need mention his discovery of that extra-uterine "early year" which located humans as secondary nestsquatters in his system of the "phylogeny of ontogeny."

A further stage for him to express his wide-reaching ideas was offered him by the Eranos Group, that "feast of souls" (Illies), which he directed for decades. Furthermore, returning to his teaching, over the years he invited his students to his vacation spots -- at Mittlemeer, Villefranche, and especially at his beloved Banyuls where he had met his adored wife.

For many students, these times at the sea-side provided unforgettable and glorious experiences. This also was the case for the short tea breaks at the tradition-rich Institute of Biology at Rheinsprung in Basel. Prominent guests often took part in these teas, guests with whom the old students and teaching staff could establish respectful first contacts. I myself remember several of these meetings which included men such as Witschi, Goldschmit, Buytendijk, Uexkill, Spemann, Koehler, and others.

After about a 25 year interruption, I called upon Portmann who was then over 80 years old. I had been asked to visit by Illies who wanted to talk with me personally at Neubad in the suburbs of Basel. Portmann came to the point at once -- to his point, of course: He had decided to complete a manuscript for a book about birds, one which he had discussed with publishers much earlier. Leafing through the work and playing with his delightful labrador, he proclaimed with emphasis, "Archeopterix is simply not a missing link; it was, even at that time, a true bird. We lack any trace of a sure proof for a transition from reptiles' scales to birds' feathers." Portmann was an evolutionist of a peculiar stamp; his new ideas were important and often the work of genius. His ideas will occupy future generations and they will give grounds for the revision of many of today's doctrines.

Heini Hediger
July 3/4, 1982

ACKNOWLEDGEMENTS

I must first acknowledge my debt to The American Enterprise Institute for Public Policy both for their award of an National Endowment for the Arts grant to enable me to begin the work of polishing these translations, and for providing me with an office and secretarial help during the period of October 1980-April 1981. The directors of AEI saw that Portmann's work had direct bearing on public policy issues, an insight which, alas, all too few American public policy institutes realize.

Next, I must acknowledge my great debt to the Earhart Foundation for several grants since 1981. Their generosity was crucial in providing me with the time to finish the work of refining the rough translations. I would especially like to express my gratitude to Dr. Anthony Sullivan, the Secretary of the Earhart Foundation. Dr. Sullivan went far beyond his required duties in helping me in countless ways, and I am deeply grateful to him.

Again, Mrs. Eric New of Bar Harbor, Maine and Basel, Switzerland, has been a generous and critically important friend to me over the last 15 years. Without her prompt help in matters as different as providing me with her wonderful food and wines while I spoke with Portmann in Bar Harbor, and checking out the copyrights of the articles, I would not be presently prepared to publish the period when these translations were being worked on, Mrs. New was a co-worker.

Again, I owe a special debt of gratitude to Prof. Frans Verdoorn, the editor of Chronica Botanica, who graciously gave me the copyright to Vol. 10, Number 2, pages 63-126, containing Agnes Arber's wonderful essay on and translation of 1790 Goethe's work on the metamorphosis of plants which I have included among the present translations.

Finally, I would like to thank Ms Lisa D. Pace who, working with me during the Summer of 1988, acted most ably as my typist, proof-reader and general *factotum*. Her never-endingly cheerful and discerning precision made a difficult and trying stage of work much more enjoyable than it would otherwise have been.

Baltimore, Maryland
October, 1989

TRANSLATOR'S INTRODUCTION

Translating Adolf Portmanns' writing is an undertaking filled both with pleasure and a certain kind of vexation. Because he is brilliant stylist, it is always a delight to follow his subtle address to vastly complex problems; by the same token, however, it is extremely difficult to catch that very subtlety in translation--and this quite apart form the usual difficulty in translating from German to English.

In all this, I have been most fortunate. During the last three summers of his life -- 1980, 1981 & 1982 -- I had the great pleasure of spending several days with him in Bass Harbor, Maine, after I had completed the rough drafts of these translations. During those visits I had the chance to discuss difficulties and his own preferred address to them, and this encouraged me greatly in a number of places where I was least comfortable as a scholar of Descartes addressing concepts which taxed the 82 year old zoologist, Portmann. (As the enclosed letters from Portmann to me indicate, we both agreed on the importance of my Descartes studies for my work with him and for my interpretation of his writing both in my translations and in my interpretive essay with which I end this book.) With a fine, and, in my own experience, altogether unique generosity, Portmann patiently illustrated point after point which was obscure to me, and never, even once, made me feel uncomfortable in facing the wide chasm separating his life-long study and mine.

On Saturday, July 3, of 1982, I received notice of Portmann's death from my friend, Yves-Pierre Simonin, First Minister of the Embassy of Switzerland in Washington, D.C. At the time that morning's distressing mail

arrived, I was preparing for a Monday class in which we were going to leave Darwin's *The Origin of Species* and begin to read some of my (then) rough translations of Portmann's essays. The news of his death renewed my determination to polish these translations for a wide reading public and so I have given all the time I could to accomplish this task -- no little one, since professional translators find Portmann's work so difficult that at least one of them, to my personal knowledge, refused to undertake the task: He said he could not make a living doing such painstaking work! My own sense of my effort is that, although I am sure I have made mistakes which no professional translator would be likely to make, I have worked with and thought about Portmann's work as no professional translator could possibly afford to do. Also, I have worked with him as a colleague at Basel, and I think that, though these translations might not be perfect, the flow of ideas and their stress are quite adequate. I am persuaded that Portmann would approve of this effort.

In closing I would like to say that this work is my attempt to repay my great debt to Portmann. He was always a fine and generous friend to me over the all-too short time we knew one another, a period covering somewhat over 13 years. When I first began to work with him in Basel in 1973, I was an unknown from an unknown college in New England. He gave me his attention and time for a year, with no real grounds for hope of any recompense. The longer I read his books and articles, the more I wonder at his enormous gifts and at his great learning. To have sat and talked with him at Basel and to have walked the autumn woods with him in Maine, are surely prize events in my philosophic life. This book of translations represents my attempt to recognize my debt to the scholar I judge to be the deepest and most vivid man I have ever met, a man who by right belongs in the company of the very best men who have ever written a book.

ZOOLOGISCHES INSTITUT
DER
UNIVERSITAET BASEL

4051 BASEL,
Reinsprung 9
May 13, 1974

Dear Sir:

Dr. Richard B. Carter and I have been in contact for several years, beginning with a correspondence concerning biological and anthropological problems and leading to his stay here in Basel from July, 1973 to June, 1974. During this period, we have worked together intensively and he has progressed yet further in his understanding of the biological viewpoint of my own work of the last decade.

Professor Carter's interest concerns the synthesis and philosophical analysis of biological theory. His own field, the explanation and clarification of the work of Descartes, has led to an enlargement of my own perspective, and constitutes what I judge to be an important contribution to a deeper philosophical penetration of the current problems of biology.

I would be pleased to supplement this letter with any further details requested of me,....

Sincerely yours,

Prof. Dr. Adolf Portmann

PART I

THE LIVING BEING AS AN OTHER-INCLUSIVE SELF

Introduction

In "The Living Thing as a Pre-arranged Relationship," Portmann discusses the implications of the evolution of opaque surfaces in living forms, and tells us that:

"The opaque surface has a unique value as a display for something visually apparent. Whether this appearance is actually seen, that is, whether it appears to the eyes of higher organisms, is perhaps beside the point in this context; we are not yet within the realm of 'visual' structures which are, it is generally assumed, meant to camouflage the organism or make it strikingly noticeable. The surface display is a part of the presentation of the self of a living being. To be sure, the perceiving eye plays no role in the life-realm in which patterns and designs first arise from these newly constructed forms; but, in that same life-realm the possibility of perceived beings already exists -- and that potentiality leads to the further promise of an enrichment of living relationships which grows out of the existence of those patterns and designs which uniquely characterize distinct individuals."

In this section on the living being as an other-inclusive self, Portmann examines the way living things relate to the world around them by means of their forms and patterns. He also discusses in what way the patterned, shaped, opaque surface, on the outside, mediates between what he terms as "the inwardness of the living thing" -- which is "a non-dimensional reality which is spatially located neither in a spacial inside nor in a center" -- and that world given to it because it is the *kind* of individual it is.

In short, this section introduces us to Portmann's thought concerning the "vital" importance of the individual living being's outward shape in relating it to its world.

CHAPTER I

THE ORIENTATION AND WORLD-RELATION OF ANIMALS: NEW RESULTS OF BIOLOGICAL RESEARCH[1]

Biological research has treated the concept of inwardness as if it were a diseased limb to be cut off; and so that concept has been separated from the main body of science by a ligature which was both artificial and extremely effective. But, to the extent that biological research wishes to be recognized as a natural science, that excluded subjectivity must be retrieved. After that, it must, with the most extreme care, be elevated to the status of an object of genuine research. This expansion of Biology may be thought of as one of the most meaningful phases of its latest development, and its place is fixed firmly beside the outstanding results of developmental physiology and genetics.

According to the interpretation of life forms which is especially widespread today, the organization of sensation and nerves, as well as the capability of locomotion, are all considered primarily as instruments in the service of the principal vital functions of all living things: Survival. These animal functions are easy to name -- finding food, locating sexual partners, avoiding enemies. In a word, animals establish just those relationships to inanimate and animate surroundings which are necessary for survival, in the broadest sense. According to this view, the central nervous system is an organization haphazardly emerging out of the materials provided by accidental living constructs in the course of indeterminate processes of mutation and selection following strict natural laws; and it is an organization which came to be in this manner which accomplishes this task.

The warbler's species-characteristic singing[2] reminds us, forcefully indeed, of another ordering of vital characteristics which differs from that in which survival holds the highest rank. What we have in mind here is a set of stages, *at whose summit* we find the animals' relation to the world being effected through its inwardness and, tied up with this, we find its self-representation within the realm of appearance.[3]

To the extent that it creates an intensification of self-representation and, at the same time, makes for an intensification of the manifestation of inwardness, the singing which characterizes a species is like play. During singing, the meaningless flow of "dead time" is transformed into meaningfully lived time; "mere time" becomes fulfilled time, that is, becomes time given form.

We know from our own experience that any mere lapse of "physical" time is difficult to bear, and that it is "dreadfully dull" to us. In just this way we know that the happy life is a timeless state where the passage of time is unobtrusive. Such a frame of mind is blissful; time then "flies"; time is then forgotten. The fact that in dreary moments we wish to kill time, to banish it, shows what a severe and unequivocal assessment of the situation is expressed even in our figures of speech. Expressions such as "time on my hands," and "whiling away the time," indicate very typical human situations involving individual problems which are social problems as well. The negative shading given to the endurance of empty lapses of time; the positive hues given to complete forgetfulness of time are both so elementary that it is perhaps not improper for us to attempt to discuss such experiences in the life of higher animals as well. The great importance of animals' activities in zoos testifies to the necessity which is found even among animals to give a qualitative form to time. As it seems to me, all animal play must be viewed within the perspective of this sense of the "formation of time." (Of course, we do this somewhat even now, but certainly not enough.) The functionless singing which takes place among immature birds and the frequent "mockery" and imitation of sounds among birds which takes place in the Autumn -- all this must be understood as the fulfillment of genuine free time. Even warblers imitate other songbirds. However, we would also do well to take note of the striking rituals displayed in higher animal life and to discuss them both in terms of their mechanical origins and with an eye to their acoustical effects -- these too, within this context of the "qualification" of the passage of time. All these rituals obviously figure in the sphere of survival functions, and an inflexible role in fixed, critical life games can be assigned to the effects of these rituals. According to the interpretation of that behavioral research which is currently prevailing, even these "functions" have an aspect which is

functionless; manifestations such as play or species-characteristic singing are free expression of this second aspect, expressions which lack the component of "role." It seems to me that this functionless aspect belongs to a higher level of living which is *served by* survival functions. The particular case to which we will now turn is the migrating bird. To be sure, we can only gain limited insight into the many phenomena presented to the biologist by bird migrations, or to the many questions these give rise to. A less restricted inquiry would require that we examine the complicated structure of hormonal glands whose work it is to provide a partial basis for the regularity of the event, and in conjunction with which the phenomenon occurs. We would be forced to look into the organization of the metabolism which makes it possible for particular species of plovers to fly non-stop over more than 3000 km. of open sea.

Here, however, we only intend to consider whether the orientation of migration, that is, to the methods of ascertaining direction which the bird employs and which integrates its journeys into the entirety of the life or its species in a meaningful way. By way of beginning, a richly portentous sign points our thinking in a new direction: If the sky is covered with clouds, starlings can be seen to be in a state of restless motion, flying in every direction of the compass. However, when the sun is shining, a distinct choice of direction begins to show itself. The sun must be the guidepost.

But how? The migration of birds does, to be sure, proceed in a relatively constant course, in the same direction, as long as the sun describes its daily arc; but how can these birds know the way when in the morning the sun most certainly indicates an entirely different direction than it does in the evening? We humans solve the problem by calculation, that is, we observe the path of the sun and then clock time gives us a second known quantity with which we can determine direction.

And here it is that research has given us a bonanza of results which at first sight are very nearly unbelievable: Namely, that a bird's brain is capable of performing the appropriate calculations for navigation; that it performs these calculations continuously and with astonishing precision; and that the bird directs its flight according to these calculations. Starlings and other birds can be successfully trained towards a definite point of the compass so

that, for example, the bird always looks, say, South for its food. We cannot take time here to discuss the particulars of the experimental methods which lead to this and other discoveries that will be discussed later on. However, at the very least an attempt should be made to describe the character of this training and its results. One of these is as follows: A starling is offered a circular arrangement of twelve feed-boxes, each of which resembles the others so as to be interchangeable, with one of the boxes, which alone contains food, always facing directly south, (See *Appendix* I). In four or five days the bird learns to seek out this box. Let us assume that the bird has learned that at nine o'clock A.M. the feed box stands at an angle of forty-five degrees to the right of the sun. If it is merely this angle of the sun which registers in the bird's memory, we could assume safely that at three o'clock P.M. the bird should again seek the box at forty-five degrees to the right of the sun -- thus now in the compass direction "west." However at three o'clock P.M., *our time*!, the bird seeks the box at forty-five degrees to the *left* of the sun: An inner adjustment of its brain knows how to "convert" the apparent course of the sun, thus making it possible for the bird to adhere to a fixed point of the compass. A sure way to determine time must exist within the inwardness of the bird. This widely varied experiment shows us that at any position of the sun, the starling finds the direction decided upon for its training, and that the bird is therefore truly capable of adjusting to the daily movements of the sun. Once trained towards a certain direction, the bird retains its training, even without practice, for quite a long period of time; a well-trained starling performs its work in the direction to which it was originally trained for up to ten months, and often even for a longer period of time, (See *Appendix* I). The bird's inner clock can be re-set by artificially disguising its day.

Let us imagine that the starling's environment is manipulated in such a way that an artificial sun rises six hours later than the sun normally would, (the transposition requires several days to effect smoothly); then, for our bird, it is three o'clock in the afternoon precisely at 9:00 o'clock A.M. our time. At that time -- 9:00 A.M. *our* time -- the bird looks "south" for its food at approximately forty-five degrees to the right of the sun. And it is in this direction that the bird does in fact look in our experiment; the bird is

therefore now directed away from the *artificial* south by a total of ninety degrees, because the time-scale required for the bird to grasp direction has been falsified by *our* interference!

Although we could easily describe quite a few particulars of these experiments, we are presently only concerned with one detail: The bird which migrates by day is equipped with a cerebral navigation apparatus which allows it continuously to determine the so-called "azimuth" of the sun -- that is, the particular point on the horizon *above which* the sun is located at any given time -- and which therefore insures the constancy of its flight course throughout its journey. We have good reason to believe that this system functions just as involuntarily as the bird's sense of time -- a sense which we humans also command. Furthermore, there seems to be no reasons to doubt that the altitude of the sun has little or no influence on the bird's ability to determine direction on the horizon -- although there is some question as to the importance of the possible control the sun's altitude might have on the ability birds have to "home" (for example, carrier pigeons), from completely alien surroundings.

The bird is not only a creature of light and eyes; it is also adapted to an incomprehensible degree to the planetary dynamics of the solar system of which our earth is a member. Today, this solar orientation does not seem quite so amazing to us since we know that a particular species of crabs, alongside the bees, are also capable of this orientation[4] -- and, what is more, we know that these tiny brains are able to orient to polarized light (when the sun is not visible). Nevertheless, we would do well to give full rein once again to our amazement in order to experience this mystery in its entire sweep -- an experience which only the most exact investigation in nature can alone give us any access at all!

When we have become appropriately struck by how very much the bird is a sun-being; by how very much the length of the day in the course of the year influences the bird's hormonal rhythm; by how the sun's course governs the bird's change of waking and sleeping patterns; then, their flight, guided by their sun organ, will appear to us as a sort of crowning of a flyer's way of being; the bird then appears to us as the most beautiful of images for such splendid day-living.

And yet, we must also note the number of these creatures of light who, during the great migration, suddenly become beings of the dark; their restlessness is the restlessness of nocturnal migration; they travel their species-characteristic migration routes in night-long flights -- and they rest during the day from the strains of this nocturnal journey. The general transposition of a creature that usually goes to sleep at dusk and wakes at dawn is itself mysterious. Although, this transposition is hereditarily predetermined, we cannot pursue this question at the moment.

As of this writing, the peculiarity of nocturnal migration has been explored intensively only in recent years. For instance, important studies have been conducted in the United States which have taken advantage of the opportunity to observe nocturnal migration as the birds move across the disk of the moon.[5] Significant advances were made in Europe using radar apparatus to record nocturnal migrations.[6] However, concerning the character of orientation toward nocturnal migration, Dr. Sauer's experiments with warblers are the most worth-while.[7] The special advantage of Dr. Sauer's observations lies in the fact that he was able to perform particular and differing experiments using warblers which he had reared individually, from the moment of birth, in complete isolation, far from contact of any sort with fellow members of their own species.

Observations of these particular birds sufficiently testify to the fact that birds isolated in this manner lapse into the restlessness which precedes migration at the time which is characteristic of their species; therefore, these observations also showed that no social "contagion" is required to bring this about. What is more, this restlessness of warblers reared in isolation lent itself successfully to close examination involving the use of a cage which was shifted to a different location every night in order to preclude completely any familiarity with the locale. Let us now consider such a cage which measures about four feet, (ninety centimeters), in diameter at the bottom. From the bottom of this cage, the only part of the night sky which could be seen in the autumn is that part where the Milky Way is located, and where the constellations Cassiopea, Lyra, and the Swan dominate the heavens, (hence no other orientation points can be seen.) When the direction indicated by their motions in the cage was observed, garden warblers, as well as hooded

warblers,were seen to display, without exception, a distinct preference for one direction, namely, south-southwest by southwest--precisely the migration direction characteristic of this species in September and October. In the spring of 1955, an experiment conducted during the return-migration phase was a success: on three distinct nights, a hooded warbler chiefly chose the direction characteristic of spring migration, namely, north-northeast by northeast.

The starling migrates by day. How it must ask itself questions about those signs in the daylight sky which give it its bearings! On their parts, experiments with warblers revealed that when the moon shown during their night-time migrations, the chart of their mapped flight directions deviated from the characteristic migration direction, and that even falling stars were noticed by them and that this caused deviation in the directions charts. Furthermore, this detail shows how closely the warblers watch the sky! Dark nights caused by cloudy skies resulted in tentative flights in all directions of the compass, and a temporary spell of restlessness. Also, experiments with polarized light show orientation towards all possible directions -- and thus no special utilization of this directional light.

There is only one set of conditions under which the warblers consistently orient themselves exactly towards their innately given direction of migration -- namely, when the sky is starry and moonless. Even if, as a result of their artificially given learning in the laboratory, they have never before been able to see a starry sky, they choose this innately given direction of migration as that one which is typical of their species.

The warbler's ability to orient itself during migration by means of the starry heavens has to be inborn. Someone hearing of these findings for the first time will certainly think this a very bold conclusion, an unreasonable demand on the impartial observer; but these findings do, in fact, allow us to conclude that the picture of the starry sky with its constellations contains the directing factors for orientation. Even when confined to the dark, the bird obviously remains an eye-creature which orients itself to the light, to forms.

An animal with an inborn picture of the starry sky! Who, even in defense of the idea of an archetypal foundation for a world-relationship, would have allowed his imagination the inordinate luxury of straying to such

speculation! To be sure, the most precise evidence has been sought and even the earth's magnetism had been postulated, and then eliminated, as a possible indicator of direction -- although, indeed, unknown physical components of the earth's force-field might possibly be able to yield the kind of orientation we observed in night-flying warblers. The possibility of decisive experimental control was first realized through the use of that well-known model of the heavens set up by the Zeiss company, the so-called "planetarium". In a planetarium, the heavens can be presented in widely varying aspects to the eye of the migration-restless warbler -- where we can vary the placement of the bird's eye without changing the conditions of a postulated force-field. Taking it as given that choice of direction is still the central issue, the distinct positions of this artificial heaven can only have meaning as directors; in this instance, these positions are the only variable conditions in the experiment as a whole.

If the results of those experiments convinced researchers that the warblers orient themselves by means of the starry sky, those same researchers must have also expected what the experiment in the planetarium revealed: The warblers oriented themselves to this artificial night-sky exactly as they did in the open air. That is, it is the constellations which control the nocturnal migrations of these small travelers. In the spring of the year, the warblers displayed the restlessness associated with migration chiefly in the direction of north-northeast; but, in the fall, under the artificial starry sky, birds chose a southern direction -- and the typical migration directions for chats, (*Klappergrassmücken*) and hooded warblers (*Mönchsgrasmücken*) are known to be southeast and southwest, respectively. However, when the dome of the planetarium was starless, the birds were just as disoriented as they are when the open sky is cloudy; they displayed their restlessness associated with migration by dispersing in *all* directions.

This artificial celestial dome gives us yet another important experimental tool; for, using it we can present to the eye of the songbird a number of distinct views of the heavens, each of which belongs to a different and foreign geographical location. To begin with, an attempt was made to present the warblers with a series of pictures of the starry sky as it would appear to the nocturnally migrating bird when seen from gradually increasing

southern latitudes. As long as the pictures were of the heavens at fifty, forty-five and forty degrees of northern latitude, the birds' flight-chart remained constant: the preferred direction of migration was southwest by south-southwest. Under the natural conditions to be found at thirty-five , twenty-five, and twenty degrees north, and therefore in the area of the Mediterranean Sea zone, very frequent preference was shown for southern flight. When, however, we artificially locate the bird beneath the view of the sky as it naturally presents itself at fifteen and ten degrees and hence as it normally appears to the bird south of the Mediterranean Sea zone, the complete transformation towards a southerly course was made. Although the bird did not at all change position, the changing picture of the starry sky was at that time able to produce a state in the bird's inner being which corresponded to its natural behavior during autumnal nocturnal migration. Beneath the appropriate position of the stars, even when the bird remains in a planetarium which is itself located in the northern hemisphere, the bird changes its course in a way which corresponds to the migration course of the chat in the Eastern zone of the Mediterranean Sea.

We wish next to discuss yet another important experiment which, if we consider it closely, will give us all the help possible to be deeply impressed by the static power of these views of the sky. In this experiment, we suddenly shine a starry sky over the warbler under the artificial dome in such a way that the aspect of the artificial heaven corresponds to a location further west or further east; then, if the view on the dome is in fact the focus of the bird's orientation, the bird will have to feel itself to be "taken off course," certainly a contingency with which the bird can meet in nature when, say, it meets with strong crosswinds. If this "blowing off course" is directed towards the east, the warbler resolutely puts itself on a western course and thus compensates for the change at once. The more the picture of the stars in the planetarium approximates the normal time at that locale, the more a turn in the compensating western course appears to the south-southwest. Finally, when the normal aspect of the heavens is restored, the chart of changes of intention shows the chat's proper southwestern course for fall migration.

Judging from all the preceding experiments, it is certain that the nocturnally migrating bird orients itself through its view of the starry sky; that the location of the constellations and of the Milky Way must be the variable factors; that the bird knows the way; and that built into the bird's inner being is a well-prepared structure for measuring time and for converting the position of the stars to the bird's own use. Orientation in wide expanses of darkness is carried off solely by means of the view of the starry sky, independent of landmarks. We are not certain of the extent to which the height of the sun plays a special part in day migration and its sun orientation, where the deviation from the meridian, the -- azimuth, is the decisive factor. However, we do know that in nocturnal migration not only the azimuth but the height of the stars is utilized by the bird in its survey of the heavens.

We know nothing of the consciousness of the tiny warbler. Hence, to claim to have something to say about the "impression" made by the changing pictures of the sky is indeed a thoroughly futile game. In this instance, the inwardness of the bird is presented to us as a whole -- although from this sphere we are certainly able to declare that there exists in the bird, as prepared by its heredity, a complicated relationship with the starry heavens: namely, the inwardness of these feathered creatures is structured from the beginning in an experimentally demonstrable relationship with the bird's view of the night sky, in which constellations, the picture-like aspects of the starry sky, are the effective elements. The extent to which one and the same species of bird makes use of solar as well as astral orientation, and even of other means of direction-finding, has yet to be further clarified. We are here in the presence of many new insights which are beginning to alter our picture of living things.

Just as happened with the discovery of the sun-compass, the discovery of the bird's navigation by means of stars is both a result of and a challenge to research. We are speaking here of apparatuses, of mechanisms, of descriptive paraphrases for yet unknown facets of discovery about which we presently know only that what we have discovered is a prepared, hereditarily given structure in the bird for the building of a rich world relationship. At this time, no one can quite imagine the concrete structure which is at work here because, in order to do so, we must first learn to rethink our cybernetic

machines -- which can perform corresponding operations -- as semi-liquid, macro-molecular forms of being. It is precisely these machines of biochemistry and biophysics which are technically still especially strange to us. (Who knows what more they will in years to come learn from their own technology?) The search for the technology of life in the area of plasmatic events is indeed one of the greatest tasks for biological work which is presently ceaselessly striving towards its solution.

However, a second task is just as important -- and how different it is from the first! This task is the integration of the knowledge about migration-orientation into the whole of the bird's life. In order to accomplish this, we must attempt to see that phenomenon in its all-encompassing reality. For a while, we must give up our perspective as inhabitants of the northern hemisphere of our earth when viewing these birds' travels. Even aside from this, biology is in many cases centered on phenomena of the northern temperate zone, and this of course forces certain "standards", whereas, other standards can perhaps be found through a study of tropical life -- or, perhaps, they cannot really be found until a world-wide comparison of very different zones has been made.

When one considers this all-encompassing relationship in its entirety -- and it is in this relationship that the bird's form of being must be seen and interpreted -- one finds a warm-blooded animal, capable of powerful flight, an animal stronger than all other mammals capable of flight, and incomparably superior to all insects in strength and aptitude for flight, (however much some insect migrations might amaze us, or, as in the case of the locust, appall us.) Everything essential to the bird's aptitude for flight strikes us as being in an hereditary, set relationship: the structure of the wings, the lungs, the tracheal sacks, the voice organs, the formation of the feathers -- whose origin is still so inconceivable -- not to mention eyes and hormonal system, and, at the head of this list, we find the central nervous system which, above all else, strikes us in this way! And here it seems appropriate for us to point out that not one single member of these systems is today seen as a particular something which has completely developed into what it is -- despite our great and unshakable certainty that these members *have* indeed developed into what they are. We may therefore not persist in

the widespread delusion of believing that we truly understand these members when, at the same time, we consider them as *continuing* to develop. The belief in this unknown development requires as a foundation the portrayal of the already existing, that is, of the life-form in so far as we are able to discern it *here and now*.

The migrating bird's coordination to the stars and to the sun; its integration into a dynamic order which works in an unknown way with the constellations and the position of the sun; its entrance into a dynamic order as a member which includes a given measure of time in order to accomplish an orientation within a world wide space to a degree which we, at this time, know of in no other animal: in an earlier time, we more clearly recognized that all this belonged to a unity of form and achievement. The order of form, function and world-relationship lies ready in the animal as a prepared field of possibilities which await actualization, as the structural dispositions of a seed await their unfolding. The potential of astral and solar guidance answers to the organs of flight and the sense of distance, that is, to the capability for a command of space of which any particular species of bird only transforms and realizes one of many sectors into a species characteristic.

This explanation may be valid only for the higher levels of organization among birds. Further research must indicate the degree of commonality of the potentialities observed among warblers. Several facts speak in favor of these potentialities being more widespread. There can be no doubt that very simple forms of life have at their command a solar determination of direction which is carried on by means of a "calculation" of the sun's position. Therefore, it is not improper for us to credit the very high cerebral organization of the bird with similar potential, even when it is not otherwise manifest. Furthermore, migratory birds are found even in categories of birds having a brain structure more simple than that of the warbler.

Because of this, it seems to me more correct to attempt the investigation of bird life within the framework of an overall view which sees the bird's world-relationship as provided with a very broad field of potentialities, in particular, with a rich store of examples of possibilities for orientation. Proceeding under such an hypothesis, it will be easier for us to understand that, in closely related species, we find kinds of animals which migrate and kinds which do not.

When we see the bird's field of potential as furnished with the possibility of freedom of movement over the entire planet, the different phenotypes are not seen as levels which ascend out of the inadequate endowments found at a lower stage up to higher forms of migration-orientation and distance-ranges; rather, they are then seen as different actualizations in a system of potentials which allows for very many variants, and in which relatively poor utilization of orientation occurs along-side richer actualizations. The way of life of the Antarctic sea swallow and of certain stormy petrels and plovers shows us the highest development of the rich store of potentialities into the living reality of world-wide migratory flight.

It seems to me that it is decisively important that we understand that there exists from species to species a different, real, development of a field of potentialities -- a species-characteristic display occurring in a field of possibilities which is comprehensively given ready-made to the bird in its very way of being. This is not the point at which we should give final shape to the questions which this interpretation leads us to ask, speaking as we presently do from the perspective of zoology. Our observations are solely intended to suggest a horizon of understanding within which biological work can be done. We are attempting to make evident, within the framework of biological research, one of the most extreme possibilities of this interpretation: namely, we have decisively settled upon world-relation, effected through inwardness and self-representation, as the highest characteristic of the living being. And it is biological experiment itself which shows us how truly hidden that inwardness is -- so much so, indeed, that our comprehension of that inwardness also includes hereditarily prepared relationships to the cosmic astral and solar reality -- a combination of relationships which strikes us here as literally "monstrous."

We are here reminded, by the enormity of the extent to which the prepared relationship reaches, of the corresponding enormity of this entire alien way of being and of the mystery of the origin of this particular inwardness. Perhaps, however, the very vastness of this prospect also leads us to meet with and perceive the mystery of appearances in its profundity. That mystery lies in the degree to which the living form, its coloration, its song, all of its modes of expression--in which all these exceed the

requirements for preservation of the individual and the species. Of course what appears is of constant service for self-preservation as well; but, just as the planetary organization of inwardness exceeds the elementary achievement of preservation, so also does self-representation in appearance rise above all mere functions of preservation.

The attempt to integrate navigational abilities into the whole of the feathered creature's way of seeing also casts light on the peculiarity of our human form of existence. Biological research is once again compelled to reflect anew on Anthropology. Someone who learns of the amazing inborn abilities of the bird might perhaps play for a moment with the thought of how regrettable it is that these possibilities have not been given to us too -- and perhaps this wishful thinking would go even further, and paint a picture of all that a brain of a complexity comparable to ours would be able to grasp by means of a hereditarily prepared world-relationship -- perhaps potentialities for a relationship extending far beyond the earth's orbit to other planets and galaxies would emerge as possibilities. One might even allow oneself to imagine a man-like animal which would be able to utilize unconsciously such a means of space orientation. But what would it be? An animal which, perhaps, would be safe in a complex way because of its orientation abilities -- but an animal nonetheless. And, what is more, an animal without the flyer's freedom of movement whereby it is made sufficiently clear that the bird's navigation system is precisely that one fitted for life in the aerial domain. And with this it appears that we have reached the limits of our comparison. At any rate, I merely intend to imply such a comparison, for I am very much under the impression that the preliminary animal stage of man, of the higher mammals, originated as already prepared from an archaic form which was very different, in the potentialities implicit in its world-relationship, from the bird's form of life.

Hominization is the coming-into-being of a new way of being whose peculiarity is, perhaps, made more obvious precisely by the otherness of high forms of life such as birds display. Migratory birds supply us with insight into an ordering of living things which displays particularly impressively a rich, hereditarily secured, world-relationship through integration into global events. Biological research teaches us about an extra-human life whose

integration into the world corresponds to a world-view similar to that used by man for his orientation in the archaic system, (one similar to the world-view of the so-called "Ptolemaic" system!), whose most precise *rational* statement is known by no other animal than man: the apparent diurnal and nocturnal paths of the sun and constellations, as seen from a seemingly stationary earth, are the regulators of the course of the day and the year.

It is entirely clear that what comprises our human Ptolemaic world is, in the case of birds, founded above all in the unconscious -- the warbler-Ptolemaics need not assemble their world-view by means of any faculty of understanding, nor do they acquire their ability to navigate as we do, through rational acts learned and performed in the compass of individual lives. The bird does not require the intensive work of imaginative and theoretical powers in order to form its world. However, despite this fundamental difference, a significant correspondence to the bird's manner of orientation does exist in the *archaic* human: there exists an originality and immediacy of world-view proceeding from the senses on which the orientation of both man and birds is based. Our spirit finds its first spiritual nourishment, its first protection in the cosmos, its earliest certainties of belief in a world-view whose sensible structures are those which, (however differently we evaluate the individuals belonging to the world of higher animals from the way we evaluate individual humans), we share with the higher animals and which in the end have led to our own world view. In this archaic way of life there are unconscious forces of world-mastery at work, even in us today, and, although they probably work quite differently in birds, their effects are not to be discounted on those grounds. Even now, in the worlds conceived by the later great monotheistic religions, this mastery of the task of existence is to be sought in an ordering of the senses in which unknown and known elements of the world-view harmonize into a general view which is completely Ptolemaic. However, while the warbler-Ptolemaics hold a firm place in their world-view, human existence is realized in the task of breaking out of this archaic world-view, of overcoming the Ptolemaicism of the spirit. The vehement wars against tradition; in difficult defeats but also in high triumphs: the archaic world-view which we have shared with the higher animals has been definitively abandoned.

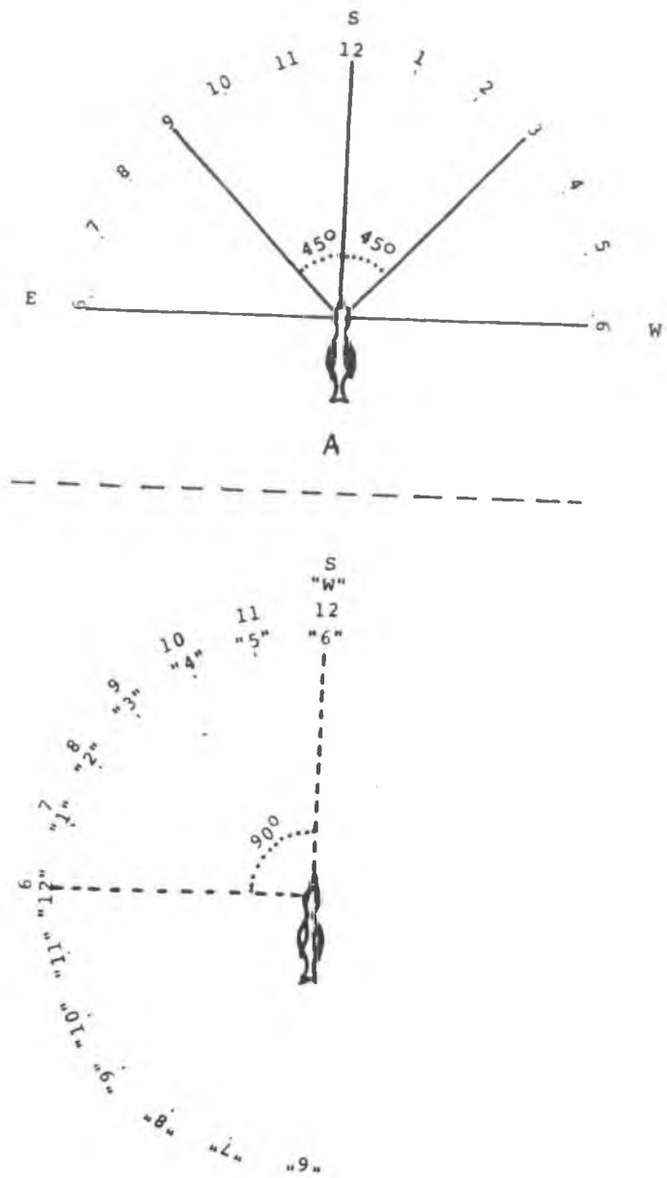
This rupture which leads us into the Copernican world-view and, over and above this, into a new astrocosmic vision, leads to strong inner tensions. Yet the world of the senses and of naive perception still remains powerful to us -- untied as it is with fundamental forms of expression of the primitive human system, and retaining significant possibilities for artistic formation in a Ptolemaic world -- while at the same time, the spirit presses towards the development of the new world-view.

Speaking by way of concluding, it is certainly not entirely inappropriate to bring to the fore the relationship of the preceding to the problem of human beings -- the ultimate occasion for my presentation.

The evidence of the birds' orientation to the heavens seems to me to be a demonstration of extra-human life on the highest level; it shows us what is possible for the organism in respect to a complex world-relationship on Earth by way of inborn means of ordering. On the other hand, the world of warblers and starlings strongly reminds us, through its opposition to our own world, of a significant fundamental fact: man is not a forlorn, lost creature facing the sheltered existence of animals who are secure in their prepared orientation to the world. The true contrast to the hereditary certainty of the animals' environment lies in that orientation which is the task of our reason, and it is given through the hereditary structural ability for *this* kind of world-mastery. In the bird, as in man, the form of life is primarily provided with a large-scale, hereditarily ordered system of orientation. While the one gives forced security to these hereditary controls, (in their highest form, this is found in the case of migratory birds), the other form of life, ours, offers the freedom of choice, the remorse of error, the night of doubt, but also the joy of success.

However, both forms of being have their origin in those hidden sources of the living being which give form to life in its particular kinds of existence; from these sources ultimately spring the world travels of the warblers, no less than man's dreams of extra-terrestrial journeys. Both are obvious mysteries. Perhaps we can benefit from several unexpected findings of scientific investigations into life by being presented with yet another possibility which is strange to us: perhaps the unexpected gives us the courage, the daring, for a new interpretation of the human. If it succeeds in this, Biology's contribution does indeed hold its proper place, that which directs our gaze towards a new journey -- towards a navigation which uses *our* endowments.

APPENDIX I



CHAPTER I
Endnotes

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CHAPTER II
THE LIVING THING AS A PRE-ARRANGED RELATIONSHIP[1]

During these times, we more and more call upon the living thing -- indeed, even upon the non-human sort! -- as witnesses to the cooperation and harmony to be found existing between all things. Within the restrictions imposed by the limitations of our organs of consciousness, we wish to grasp fully and richly as possible the workings of a unity of which we are aware even though it is presently hidden from our consciousness. Therefore, we might do well here, at the conclusion of our conference, to come back to this living thing to see how relationships really are usually established, and how they become comprehensible to us. In the course of this attempt we will keep in mind relationships which are conscious and those which are not. I will chiefly discuss those living things which present themselves to our senses within the scope of our normal experience -- that is, I will chiefly address higher life forms. In particular, I will address my remarks to those animals which are the chosen realm of my life's work and study. Our presentation will begin with a group of creatures whose relationships are meager -- that is, meager if we use our own potentialities for relationships as the standard of measurement. To this group belong the jellyfish and polyps, and many of the segmented worms, as well as the arthropods, among which we find the lowest forms of crustaceans and insects.

The effects related to form which are a part of the life of such animals can only be trivial, and there are no effects whatsoever which depend on images. Relationships to the locality are effected through light and darkness, perhaps even involving colors; through heat and through chemical stimulants; also, it is effected by the force of gravity -- often through the agency of the statozutes which are special organs for the sensing of position -- which thus contributes to the animals' perception of its locality. Above all, the relationships of organisms of this level of development to their environment -- and this holds true as well of other kinds of animals -- are *chemical* in

nature. But we do not mean to say by this that these modes of activity are all that simple; indeed, the range of possibilities to be found within the spectrum of chemical influences can be astonishingly broad, as the example of a small marine annelid, (*Ophryotrocha puerilis*), shows. For, in this case, we find chemical stimuli at work which lead to the alteration of the individual's sex. We shall consider this process for a moment. It doubtlessly takes place entirely within the realm of the unconscious, but it may nevertheless still point to hidden psychic potentialities which could also affect human society in an unconscious way. Indeed, the more we reflect on the peculiar effects of a substance such as mescaline on humans' perception of the world, the less likely are we to take the influence of chemicals on the life of animals lightly.[2]

If we allow two fully grown females of this species, (*Ophryotrocha puerilis*), to live together in a basin under optimal circumstances, then, after a short time the female containing the fewer number of eggs undergoes a new and unexpected development. The ova are re-absorbed and hidden male organs mature in their place. These create sperm which then fertilizes the spawn of the other female. Should such a pair remain together for any length of time, the egg-laying partner would be able to produce up to four spawnings before being depleted. Then, however, the partner which up to this point has been transformed into a male, develops its eggs while the depleted female turns into a male and in turn fertilizes the spawnings of the other. In order to understand this singular occurrence, we must remember that in all animals, the original gametes are bisexual, and are therefore able to develop into spermatozoa *or* ova, according to their hereditary pre-disposition and the inner *milieu* of the animal. It has been experimentally proven that chemical extracts are able to effect sexual alteration. What we are addressing ourselves to is thus a matter of chemical influence. It is important for us to remember that the living system of the *Ophyrotrocha* is an androgyne from the very outset, and that it is therefore genuinely hermaphroditic; thus, both sexual pre-dispositions merely await the chemical summons to activity. The joint future relationship of the sexes is already pre-arranged in this twofold hereditary pre-disposition of the germ; the way in which the male and female come together is also anticipated through this pre-formation. Absolutely everything we know of sexual behavior in the

human realm originates in precisely this same way, that is, in the hereditary pre-dispositions which are pre-arranged in every individual for *both* variations, even though *only one* of the sexes reaches full development.[3]

But, as poor as this realm of animal forms may be in its relationships, it shows us something further which is essential for our grasp of the living thing: that is, it shows us the harmony existing between the inner and outer structure. The symmetries between the outer form-structure fully corresponds to those of the inner structure. The thoroughgoing unity of the building plan which in higher animals is only realized during the stage of its earliest developmental structure, remains life-long when we come to this low level of form. The frequent phenomenon of complete transparency among these forms is particularly striking, and it can sometimes be softened to an opalescent semi-transparency. We would do well not to view the facts associated with appearance as arbitrary, immaterial trimmings of an animal form-structure; rather, we should be able to perceive such a transparency as an important article in the manifesto of these creatures, even though the "speech" in which it is expressed, and thus in which a form of life presents itself, is completely foreign and incomprehensible to us. That an organism allows itself to be seen into and seen through is a part of such a manifesto of a being.

We become witnesses to a very peculiar transformation as well when we find complete transparency among higher types of animals. In this group, the organs of metabolism become unsymmetrical and forced together into an extremely narrow area. This happens, of course, because those organs are always structured according to the individual's capacity to perform tasks. But, by means of a shining opalescent or luminous red, orange, or blue-colored covering, this area containing the organs of metabolism is given the effect of a uniform color. The result is the so-called "*nucleus vegativus*." The rest of the body, however, transparent as glass, becomes greatly increased in size and is structured according to a rigidly bilateral symmetry. A style of construction such as this, including a strikingly tangled knot of intestines, is exemplified by the "wing" snails, (*Pteropoda*), which live in the open seas, and among the wedge-foot (*Heteropoda*), another group of ocean-dwelling snails, as well as among mollusks and transparent species of fish or their larva. The

concealment of the unsymmetrical intestines, whose agglomeration results in a tangled knot, within a "nucleus," doubtless has many aspects -- and one of these is that a rigidly bilateral symmetry is realized within a *transparent* body!

Looking over all the form-structures we find among animals, we are led to think that perhaps these transparent or semi-transparent beings are the life forms in which the actual unity of a plastic being is least divided into a conscious and an unconscious component. We are very widely separated from this transparent life; we can hardly guess at what such a life could be as a complete and total existence.

The entire mystery of our own unconscious side is here vividly revealed to us, and an event which becomes an important foundation for all higher life is found to have its place at a level of life where relationships are as poor as these are. The surface of the organism's body can be either completely opaque or only opaque in places; transparency is thereby rescinded. The transition from the transparent to the opaque animal results in a differentiation between *Inner* and *Outer* which the transparent mode of organization does not display. In the inner structure, particular laws of form apply. Here, complete utilization of cavities within the body is stressed along with the increase in the surface of the organs of metabolism. Only the very earliest phases of life show the original inner symmetry of the layout of the organs; as a consequence, asymmetry can often appear very early. However, the outer structure displays a highly geometrical regularity of arrangement which is, without exception, bilateral -- even in those cases where the appearance suggests an almost purely radial arrangement. Thus, the basic bilateral arrangement of the sea anemone, the starfish, and the sea urchin can be discovered by close examination, although at first glance, their organization appears to be a radial one. This difference in the structure of the inner and the outer heightens the dynamic and the potential of the entire life form. Intensification of an individual's metabolic processes increases the inner organs and this, in turn, results in the enlargement of the exterior -- thereby opening up avenues to a more intense way of life which, in its turn, leads to an enrichment of the ways in which the organism can form relationships through more complex capabilities for sensation and forms of motion.

But, in becoming opaque, these outermost surfaces of the animal form turn into a new organ. Along with that new organ arises a new, two-dimensional reality which is largely independent of the inner structure. Such a surface is not merely a "border," not just a barrier for the containment of an inner *milieu* or for the safeguarding of metabolism, that is, for mechanical protection. No. This surface becomes an organ with entirely new potentialities. The example afforded by the sea anemone, by many marine flatworms, and by lower insects and crustaceans shows us in what way the surface is utilized as a field for displays, for a colorful expanse of designs. The opaque surface has a unique value as a display for something visually apparent. Whether this appearance is actually seen, that is, whether it appears to the eyes of higher organisms, is perhaps beside the point in this context; we are not yet within the realm of the visual structures which are, it is generally assumed, meant to camouflage the organism or make it strikingly noticeable. The surface's display is a part of the presentation of self of a living being. To be sure, the perceiving eye plays no role in the life-realm in which patterns and designs first arise from these newly constructed forms; but, in that same life-realm the possibility of perceived beings already exists-- and that potential leads to the further promise of an enrichment of living relationships which grows out of the existence of those patterns and designs which uniquely characterize distinct individuals. That opaque surface also implies the power to establish relationships. We should not depreciate what appears on this surface by thinking of it as a "front," an incidental extra which is plastered over a far more genuine and authentic "inside." No greater allotment of reality or honor can be ascribed to what is hidden than to this appearance we derive from an opaque, patterned and designed outermost surface. Indeed, the inwardness of the living thing is a non-dimensional reality which is spatially located neither in a spatial inside nor in a center. Rather, an active "medium" or "midst" is present within the entire animal. The potencies implicit in fragrances or sound-production also belong to the sensible realities of the realm of appearances: that realm is always active in its casting itself abroad into the world, and, in so doing, it acts on a sensitive inwardness which experiences that activity. Whether through sight, smell, or sound, appearance is always working on the surroundings and thereby also on

an inwardness which assimilates these effects and which itself experiences appearance. This activity which affects the sense extends the reach of the individual and adds to its experience. However, such an enrichment of the animal's communal life should not be seized upon as being the origin of social forms of life. For, that enrichment does not locate the origin of social forms of life in the primary stage where we find isolated individuals. Rather, this enrichment acts on an already prepared foundation of "sympathy" or affinity through the structures by which the animals make themselves known. It is only this pre-disposition which, transcending the solitary mode of life from the very beginning, leads to the recognition of and the search for others of like kind; and, in fact it is just this very disposition which makes it possible for the unfolding of that system of self identification to others. The individual is never alone, but, through its dispositions, it is already more than a solitary individual.

The cutting off of inner from outer, the breaking away from the original transparent and thoroughly symmetrical structure to create a new level of living things and make possible the internal construction of a complex central nervous system in which, at an ever-increasing rate, conscious experience arises as a special way of being: this way of being releases a distinct part from the great unconscious workings of the living thing, a part which then serves as the center of its own bond to the world.

Corresponding to this growing centrality and consciousness are the possibilities for optical structures and display as well as for other sense-perceptible modes of appearance which result from the surface becoming opaque. The more powerful inwardness, possessing as it does a consciousness, is ever more and more able to sense the appearance-aspect of the organism. The boundary of the organism becomes the organ of this inwardness; the very outermost speaks quite particularly of the very inmost.

In this role, the opaque surface takes over various roles whereby the animal manifests itself *as* itself. We emphasize primarily the optically perceptible role as that one which is representative of other possibilities. The stress on those distinguishing features which are optically perceptible grows out of the fact of the wide dissemination of the optical orientation and of the ability to see a picture or image, an ability which is particularly

characteristic of the highest groups of animals which possess form-structures. This self-manifestation is in the service of the self-description of an animal type; furthermore, this self-manifestation conveys announcements concerning the change of the entire inner state through its changing appearance, as, for example, in the sequence comprising immaturity, maturity, the age of sexual vigor, and then of old age, a sequence found in a quite uniquely distinctive form among the higher vertebrates. However, the surface also becomes the site for this presentation.

A dazzling wealth of structures is opened up to our eyes when we observe all these displays of self-presentation, but the skin, and the entire surface of the animal, are quite often understood as exclusively comprising organs for mechanical protection and, among warm-blooded animals, as comprising organs for temperature regulation and hence as a kind of adjustment to environmental conditions! Only the influence exerted by a changing conception of the organism will lead us to take into account the fact that innumerable structures of the skin are, in various ways, primarily in the service of the picture we get through appearance. My presentation is made to argue for the necessity to make that change in our view of the organism. However, currently accepted conceptions of animals are pitifully incapable of dealing with such images. These conceptions only help to give the animal a name within our collections, to "define" it systematically. With this devaluation of appearance, one of the most astonishing things about nature disappears from the nature-lover's horizon -- for both the researcher and the layman, the undreamed-of richness of phenomena falls entirely into oblivion, or it is looked at as a *minor* detail!

And yet, once we re-orient ourselves in our views, it is precisely the realm of self-presentation which turns out to be an essential attribute of the living thing's way of being -- not as irrelevant, but as a meaningful part of the living thing's form-structure. The scales of butterflies and the chitinous shells of insects give the appearance of metal, of gold and blue textures, appearances whose sense surpasses any merely adaptive activity. The feathers, hair, and scales of the vertebrate animals, together with their nerves and muscles, are, in their color and form, visual apparatuses which are specialized in surprising ways to serve viewing eyes. The blood-vessels of the

skin are not only support systems or apparatuses for the regulation of temperature; the skin's capillary network is an important means by which color is intensified. The rich integration of the blushing and paling of our facial skin into the service of the expression of feeling and the manifestation of quite subtle psychical reactions, e.g., the feeling of shame, is an extreme example of these relationship-structures. That the border surface of an animal becomes opaque opens an entire world of these kinds of relational possibilities.

Our account so far has presented only one side of these possibilities -- that one which we might compare, in terms of human technology, with the broadcasting equipment of a radio; but answering to these broadcasting-organs are new, equally important, receiving instruments within the central nervous system. Only when the two work together are the potentialities of the surface made into correlates of a richer inwardness. The interdependency of the increased centrality and the new organs of the animal's opaque skin cannot be stressed too much; indeed, that interdependency becomes a criterion for that very intensification of the mode of world-relationship which first gives us the right to speak of higher animals. But, with this interdependency, the outermost appearance can also be defined as an important correlate to this inwardness which is a truly complex non-spatial reality. The opaque surface creates relationships between organisms and, simultaneously, relationships to the world around them of the kind which do not exist for the transparent creature within the realm of purely chemical contacts. It is the effect produced by pictures, by "configurations", which, in the higher animal, gives occasion for that action and behavior which can, on the one hand, alter the animal's inner state, its mood, and, on the other hand, trigger the appropriate action when the animal is in a special mood. Because of the activity of such pictures, even incomplete glimpses of a larger complex of appearance can alert a viewing partner as to the consistency of the inwardness which is at work or, as may happen, of a changed mood and disposition. All this requires the help provided by the structures belonging to the outermost surface of the partner being observed. A new complexity of relations between living things is brought forth because of these activities of pictures -- a complexity which is

far beyond those found in the relations existing because of chemical agents. Along with the increase in complexity, however, the danger of failure is increased: as is always the case, the higher is also the more endangered.

When we look at bird life, (and other higher animal groups offer similar evidence), we see that homosexual attachments will occasionally be formed when the birds are pairing -- an occurrence which is based on the effect produced by images. In pairing, the presentation of sex roles makes use of the means by which the parent/child relationship is manifested. Thus, for example, the ceremony of submission or of child-like begging is equivalent to female behavior. Then, under certain conditions, this role can also be played by the male partner in pairing. Kortland, in his painstaking studies on cormorants, has made observations concerning this kind of pairing between members of the same sex when, say, a superfluous male is found in a zoo, or when, in other instances, single females are found in the wild.[4] Among such pairs, the one partner is able to assume the role of the opposite sex to such a degree that a normal male will produce the peculiar gasping cry of the female. Also to be found are cases in which a male cormorant can play the part of a male to a female cormorant, but, when encountering a male, it can pose as a female. Such situations also occur in the wild, but as exceptions. They are based on the fact that a bisexual pre-disposition prepares the possibilities for the self-manifesting system of both sexes beforehand. The very possibility of failure within one functional sphere and of success in another indicates the significance of all structures designed to announce and, in particular, to announce the emergence of a new life-form which has its own worth and sense and its own fulfillment which can be isolated not only from the elementary tasks of the mere prolongation of existence, but also from the mere preservation of the species. With the effect of "pictures" as that which stimulates an individual act, a heightened form of individual worth is found to have arisen, an event which took place as early as the time which saw the appearance of the higher animals on earth -- an elevation of the individual which among humans occurs in an especially extreme way.

This elevated life-form emerged out of a simpler level of form through the development of optical modes of activity. Once the higher form

has emerged, however, then a wide realm of sensation can develop which brings with it a new intensification of that higher form's hold on the world -- e.g., the relation to the world which is established through sound. With sound, acoustical modes of self-announcement can emerge within the realm of appearance and, in the central apparatus of inwardness, the appropriate new organs of receptivity will emerge. Vertebrates realize the potentialities of these sound-pictures with the help of their respiratory organs in which the respiratory tract and its co-ordinate musculature are utilized for sound-formation. In this group of animals, the auditory organ is created by a distinctive elaboration of elements found among the organs concerned with position. In contrast to this, insects, the other large group of hearing animals, develop special structures which are exclusively in the service of the production of sound and the reception of tones. We will take this particular broadening of social relationships among insects as the starting point of the second section of our survey.

Sometime around the beginning of August, we notice that our forests have become stiller; but then the chirping and shrilling of grasshoppers begins in warm groves and on the slopes of the mountain. Focusing our attention on the field grasshopper, we will do what we can to listen in on this small resounding world a little more carefully; for, in this way, we will become acquainted with the full richness of the acoustical form of relationship. Among grasshoppers, both sexes possess organs of hearing which are located well to the front of the abdomen. With their tympanic membrane, tympanic cavity, and sense-organs positioned behind them, these correspond fairly extensively to the order of elements to be found in our own ears. In contrast to this, it is only seldom that the organs which produce the grasshopper's shrilling are possessed by both sexes. Indeed, without exception, the female only shares a meager capacity for expression. Here in Switzerland, careful experimental researches on fifty species of grasshoppers were performed on species in which the males were found to chirp; out of these, nine species were definitely identified in which the females also produce sounds.[5]

In the group of grasshoppers which we are now considering, the sound-organs are positioned according to two completely different building

plans. One group -- the zoologists call them the Stenobothrus type -- develops a row of pegs on the hind leg, over which the wing vein is positioned. In contrast to this, we find another variation -- which we call the Oedipoda type -- which forms the pegs on the wing-vein itself, and develops a stroking ridge on the hind leg which serves as a violin-bow. The difference becomes intensified by the fact that the particular vein in the wing which is modified for shrilling in each of the two types is not the same one. In addition to this, there are isolated cases in which even more widely differing sound organs are to be found. This diversity of development is not simply a matter of concern to the specialist; indeed, we mention it here because the question of the origin of such sound-organs is complicated by their very multiplicity. In any case, however, this diversity forces us to draw the conclusion that in one and the same group of forms, the production of sound must have had its origins in the use of different instruments independently and in several distinct cases! There are several opinions as to whether this shrilling should be designated as "song," nevertheless, because this usage has been adopted among biologists, we will, for the time being, speak of songs and of singing. A precondition for all singing among grasshoppers is that there is sufficient heat and radiation; there is a good reason why the entire concert will occasionally fall silent at the slightest presence of cloudiness -- even on a quite warm summer day. In what follows, our investigations will usually be concerned with the song of the male because that case is representative of the general case. When the male song resounds fully, it is always a quite reliable expression of the fact that the grasshopper is in the mood to pair; its song constitutes an announcement of its readiness for encounter which is audible from far away. When the individual is completely mature, this song is a spontaneous expression; that is, above all, it is a clear case of self-gratification and a manifestation of the animal which, however, can have that far-reaching effect on species members which is characteristic of an act of communication. This, in turn, expands the extent of the reach of the individual considerably. In cases where the singing of a male is answered by another male, then, what was at one time the mere casting forth of sound into the surroundings passes over into an exchange-singing or anaphony. This anaphony, in turn, has two quite distinct expressions. When one

partner's voice is relatively steady, with the pairing-drive not very strong and the distance comparatively large, (e.g., more than a meter wide), the anaphony then remains a simple *responding* which can be kept up for a long time with a regulated detachment. Here, the strophe is very richly executed and quite often variegated with playful freedom. However, when the mood for pairing is strong and the distance between the males is minimal, the species-characteristic sounds which strike the organs of hearing operate in another way. The partners reach the point where they act as rivals. At this stage, their singing is thematic and thereby richly charged with a message. In behavioral research, the terms "message" or "motif" refer to individual sub-groupings cut out of the usual song-pattern. Among some species, this rivaling will begin even at a distance of 50 cm., while among others the approximations to one another must be increased to 12 cm. in order to trigger this strongly emotional anaphony. Among males, the result of this powerful rivalry is mutual repulsion; they retreat from one another to that distance at which the usual response -- lively within measure -- is once again set off. The result of this is a definite marking off of territory through this sound production. Careful observation clearly shows that this rivalry always separates the males from one another and thus takes the place of the territorial battles of other sexual rivals; these observations also show that the act of responding keeps males in social contact. This sort of concert has a stimulating effect on all the members of a small district, without, however, leading to excessive agitation. As in many other social modes of behavior among animals, a double end is here reached by a single path: one and the same act of sound-production eliminates the bloody battles of rivals and thereby also the possibility of substantial loss to the species; and, at the same time, it creates the stimulating social contact which is essential for all higher animal life. The desire to give a more or less complete picture leads me here to give one more special instance as an indication of the many-sided character of such sound-production among grasshoppers. Among the species, *Chorthippus montanus*, we observe males approaching one another very intensely. While this is taking place, we find that these animals produce soft, continuous contact sounds, and in this way they "chat" with one another

over a period of time which can be quite extensive. The role of this social contact made possible by sound seems to be especially important here.

The particular answer which will be elicited by a given song is a matter which is hereditarily defined for both sexes. If, on the one hand, the anaphony of the males sets up limits such that when their proximity exceeds a quite certain and definite limit, their song results in repulsion. On the other hand, it powerfully draws the females into its spell. At the same time, song is no less in the service of the *acoustical* recognition of species members. To be sure, their species have already been identified optically; but their sex has not yet been grasped. The behavior exhibited at the hearing of the song -- that is, approximation or withdrawal -- then discloses the sexual nature of the individual grasshoppers who face one another. Now, when the female grasshoppers sing, their tones produce a powerful, stimulating effect on the males. We might here do well to point out that, without exception, the females sing only in answer to the sounds made by males; the song of females is not at all spontaneous. In species where we find this female song, the courtship ceremonies are very strikingly curtailed. The ritual of pairing gains certainty in reciprocal singing; such a complication certainly has a species-survival value.

Let us look over our findings on grasshopper song once again. These insects live with a structured field of hearing: That is, given any suitable physical area, a kind of district is carved out which, in a special way, belongs to these individuals -- but only on the basis of the borders set by this rivalry-singing. As is the case with smelling, the formation of tones and the grasp of those tones through hearing also widens the realm in which the individual lives. The animals stand in a reciprocal contact with their kind -- with the males of their species no less than with the females. There exists a supra-individual realm of sympathy which is bound up with the sun and which, during moments of shadow, is engulfed in the stillness born of a lack of stimulus. This way of life extends beyond the grasshopper's sense of distance and beyond its own doings, and, still further, beyond its corporeal borders. The sphere of tension centered around hearing and chirping outwardly manifests the particular centrality, the particular non-spatial inwardness, of the animal. These individual beings have been more than individuals from

the very beginning; they are supra-individual in a manner which is consonant with their structure and capacity. The song of the grasshoppers at the sinking of the sun testifies to the strength with which the social factor characterizes the way of life of all higher animals. The "we" has priority over the "I" and is always more than the "I".

But, when we turn our attention for a moment to the beginnings of an individual life, the grasshopper song shows us yet more. Insects of the order *Orthoptera*, to which our singers belong, undergo a larva stage and grow throughout four and sometimes five sloughings of the skin before attaining their mature form-construct. At each sloughing, the body size is increased, with the wing-length showing especially striking gains in size. Between the second and third molt, the grasshopper begins to behave strangely. Its legs begin to perform the movements for what will later give its song. Now, at that time the number of pegs on the chirping-apparatus is already complete, although the ridges for shrilling are still small, but its wings do not yet *reach* the legs. Thus, the grasshopper-violin is not yet ready. In contrast to this, the central part of the brain is already complete and it forces the young individual into a mute "larva-song". Thus: *The individual's behavior matures before its outer instrument*! And this maturing occurs by means of hereditary generative processes which involve absolutely no learning. Let us trace this development back one stage. Those grasshopper species which manifest themselves in song are always separated into two sexes; the individual never appears in any other way except in the special display of one sex. But experiments clearly demonstrate that both sexes, through the pre-disposition of the ova, already bear within them their two-fold potentiality. Which mode of relationship will emerge between the two sexes is already prepared as a two-fold pre-disposition in every fertilized egg. The ova's potentialities are in excess of what is actually realized in the later completion of that manner in which the individual completes its form-construct: Its pre-form -- its draft or blue-print -- is richer than its execution. The completion of the individual's formation presupposes a curtailment of one part of that individual's heredity and the full attainment of the form associated with the other part. For both sexes, the totality of those potentialities which later give rise to song are pre-fabricated through hereditary structures. These potentialities also include

the individual's quite particular inner state, since it is some entirely particular inner state which is the temporally immediate occasion for each and every act. The all-decisive inner state is the individual's mood. "The individual's mood": this expression refers to a harmony, to a special sympathy of many things. The experimental biologists are finding that precisely this mystery, mood, is the immediate determinant of action, and that it is hereditarily prepared. The potentialities for mood determine both the extent and the contents of the individual's world-formation; those potentialities regulate what the individual will experience in reality.

The entire succession of developmental phases is already present in the ovum, and in each phase this preparedness, this readiness, is adjusted to the continuous succession of possibilities; in each phase, groups of moods are laid down in such a way as to determine the mode of world experience characteristic of each event. The open positions in the system are also pre-arranged throughout the entire developmental path. These positions, what is more, have the ability to lead to the formation of new relational modes -- but only in conjunction with experience. However, it is the preparation effected by heredity which controls the *extent* of this openness and thereby the new world relationships which are only later minted in the course of processes involving learning. So, we are also here faced with an hereditarily given situation when we find that the entire mode of development and the mature form of humans is stunningly open to the continuous reception of new events, to the acquisition of newer and newer modes of behavior. The question as to what might thus be the hereditary structure underlying this pre-arrangement for such human openness encompasses the tremendously difficult problem of archetypes -- a problem which occupies the attention of such an essential part of Eranos' labors.

There is only one way for us to judge fully either of the peculiarity of the pre-arranged world-relationships of living things or of the role played by the structures comprising their opaque outermost surfaces: and that is, our grasp of the organism must integrate these facts, (once their proper place has been determined), with their proper worth. Biology's contribution to the construction of the forms in which this integration takes place seems to me one of the most important contributions it has to offer us towards the full

development of our peculiar relation to reality. The urgency with which a new grasp of the organism is called for is entirely determined by the extent to which the generally accepted view entails an alienation from reality and, it should be noted, any deficiency here gives rise to a correspondingly incomplete picture of the living being. The true dimensions of the problem of the relationships of living things to one another can be seen only when our basic grasp of the organism has been completely transformed. The currently prevailing view is presented by dictionaries and textbooks -- as a truism. It tells us that the central issue is the *self*-preservation of the organism by means of its metabolism and its development, i.e., the process whereby it constructs that very self. Alongside these, we find *species-preservation* by means of propagation, and *species-transformation* by means of mutations. The relative ease with which certain structures allow themselves to be assigned to the functions of preservation, and thus which make it so easy to create a method for understanding, has been particularly helpful to the promotion of this narrow vision of things. The significance of physical-chemical methods, technically important as they are, along with their historical role, has led to a tacit recognition of an hierarchy of functions in the organism which entails the attempt to reconstruct the unknown whole out of "elementary" predecessors of life. In keeping with this view of the matter, earlier speculations resulted in an understanding of the cell as the elementary organism and, when it was a matter of nerve-functioning, of reflexes, or, in genetic research, of the genes found in the cell-nucleus. Of all the organism's essential activities, metabolizing and the preserving of species have attained to the dignity of "elementary" functions, that is, of functions which are uniquely important for life. As a consequence of this approach, a great number of characteristics peculiar to the living being have been excluded from the category of vitally important distinguishing traits; at best, they are conceded a "taxonomic" value which is only useful for the determination of species-membership. This view completely neglects a vast number of just those characteristics by means of which an individual is distinguished by its external appearance, and it has only been the behavioral research of the last two decades which, *de novo*, has established their worth -- indeed, in a way which was entirely unforeseen!

The insight which guides our own presentation sees nature as a monstrous, unfamiliar, dominating unit. This incalculable thing, real and unfamiliar to us, comprises the wide field in which the labors of all investigations of nature have been carried out. Within this unknown are to be found living beings with a distinct level of inwardness which stems from distinct degrees of wakefulness and distinct capabilities for work; all these act as centers for spontaneous alteration in living beings, each one of which is, without exception, before us as a whole -- prior to any analysis. The living being is unknown to us in its wholeness. Within the inherent limits of any knowledge, we grasp only snips of its workings. The darkness of this entire mode of being and the fragmentary nature of any scientific insight must both be constantly before our eyes when we seek to understand the interdependency of living things. The hierarchy of values according to which we classify the functions of the living individuals cannot be dictated through the mere order of precedence to be found in the methods of physical and chemical research. The problem of how to rank work is quite distinct from that of the best method for research, which always concerns the field whose methods are being used in the investigation. We must make it clear to ourselves that the ranking which we still find expressed in current definitions of the living being has been all too exclusively dictated following purely methodological presuppositions; it has not originated in the nature of the object. The crucially important factor in deciding upon a theoretical approach which strives to see all that is comprehensible about the living thing is nothing less than the whole peculiarity of the living thing. However significant the potentials of research seem to us, particularly in the cases of physics and chemistry, and however immense their practical, technical significance may be, we must still place our insight into the relative autonomy of the life processes at the center of attention. It follows that we cannot restrict ourselves to the investigation of the material components of the living organism, but that the living being must be grasped in its full peculiarity. A part of this peculiarity, however, is the total appearance, in all its wealth of possibilities for the display of the organism's centrality or inwardness. Our point of view thus forces us to construct a new hierarchy involving the distinguishing features of the living thing and, in what follows, I would like to

present an overview of that hierarchy. The extent to which these identifying characteristics can be grasped through various research efforts is dictated by their particular methodologies and by the corresponding technical possibilities of their types of work -- and, of course, by their further development in the future.

Among the fundamental givens of our experience, we find individualized beings whose inner activity builds up a world-relation using a number of resources which differ greatly from one another. Even as early as the embryonic stage of development, we find essential features which. on account of hereditary structures and processes, pre-dispose the individualized being for that building-up of those world-relationships. Distinguishing features of the living things, such as sensibility, nerve activity, sense-functioning and movement are members of this most comprehensive pre-condition for world-relationship. We call the totality of this world-related activity, "inwardness" -- an expression which indicates a non-spatial reality which is altogether distinct from the term, "inner organs" of the body.

The activity of this inwardness confronts us in the distinguishing characteristics of the appearances--namely, in the large degree of distinctiveness we find among sense relationships: Above all, any given appearance must be grasped as comprising a *self-representation* of a particular protoplasmic being, where we must take the term, "appearance", in its widest possible sense. The distinguishing optical, acoustical and olfactory features which emanate from the static form-construct all belong to this self-representation; but so does its manner of movement, its forms of expression--indeed, all of its manifestations in space and time. A phenomenon such as bird migration must also be grasped in this way, that is, as a constituent part of this most outstanding feature of life, as a part of a many-sided self-representation which indicates a particularly high degree of organization. The distinguishing features of self-representation are, first and foremost, peculiarities which endure beyond any function of preservation, beyond any selection-value, beyond any utility, and which are presented to us as a primary given of the living thing. The concept of "self-representation" is descriptive; at the same time, this concept should remind us of the fact that even the most widely dissimilar functional correlates as, say, activities in the

realm of species-preservation, metabolism, etc., are not sufficient to explain the distinctive mode of being of a characteristic feature. The consideration of self-representation as a supreme peculiarity of life carries with it the justification for a comprehensive, self-supporting theory of forms. Morphology, whose limits have always defied any easy specification, is the science of the self-representation of the organism, and, working with physiology, it clarifies those special characteristics of form which are to be understood as adaptations to the environment, to metabolism or to species-preservation. However striking we may find the images in many of those living forms which are in the service of these preservative faculties, these structures are nevertheless all parts of a whole, of a whole, what is more, which cannot be understood as a sum of such preservative apparatuses and faculties.

The characteristics of the living thing which have been hitherto most widely noted fall into place only within that wide field which encompasses both world-relationship and self-representation. Since these characteristics are taken into consideration in all current popular presentations, we can here be brief and simply enumerate them. We see, as we scan this literature that their main concerns are *self-preservation*, which involves all organs and processes of metabolism and regulation, and, falling into this same category, we also find *self-construction*, and this includes the totality of the ontogenetic precedents and the processes of regeneration. What is more, these fundamental characteristics which are peculiar to living things include *species-preservation*, (or propagation), which proceeds along both asexual as well as sexual paths. With the last of these fundamental characteristics, *species-mutation*, we are faced with the entire problem of evolution and we stand once again before the darkness of reality, that darkness which research seeks to illuminate.

What we are here working to present stands in opposition to all the attempts to "construct" the organism out of elements -- for instance, appearance out of cells, or behavior out of elementary functions or reflexes. Even in the case of hereditary factors -- the importance of which has been amply demonstrated by genetic research -- we are still only looking at constituents, and not at the final unities!

We start with the insight that the whole of the organism is given to us as the reality of experience, and that this real presence transcends the possibility of understanding from the start. As a consequence, all our research must be carried out as we constantly keep the hiddenness of the present in mind. Only such a picture of the organism can preserve us from the disastrous error which the investigation of nature has so often committed, namely, from that error in which the workings of things are identified with that merest snippet which research has laid bare. Only a comprehensive concept of the unknown workings of things can enable us to recognize actively the full extent of the relationships of living beings to one another and their relationships to an inanimate nature.

But we now want to turn away from these general deliberations to a particularity which will make it possible for us to comprehend the peculiarity of the living thing as a pre-arranged relationship. We will look at one of its manifestations. I have chosen an example which is especially well-suited to that kind of world-relationship which Eric Neumann has often presented in his lectures as the realm of "alien knowledge."

A hungry viper coming across the scent of a mouse is alerted by that scent and seeks out the hole into which the mouse has disappeared.[6] As soon as the victim appears, it is bitten. In the course of this biting the victim, owing to the special structural apparatus of the viper's oral cavity, is seized by two large venom-fangs and venom is injected into the mouse which is then released by the viper whose venom-fangs are then withdrawn. Next, surprisingly enough, the viper allows the mouse to run away undisturbed. The snake conducts itself as if it knows that the poison will work its effect within a few seconds, and that it will, without any question, knock the mouse unconscious within at most three minutes. What the viper consciously experiences and so, by our lights, what it "knows", no one can rightly say. Nevertheless, observation teaches us that the system of the snake's world-relationship is so structured from the very onset that it includes this "alien" knowledge: A pre-arranged relationship through the structures of the central nervous system which dictates behavior. We are all immediately struck by how exactly this anticipated structure of a behavior corresponds to the archetype which depth psychology also meets with in humans.

After some time, the viper brings its search-motions into play. This phase of the viper's behavior has been especially painstakingly investigated as follows. The synthesized scent of bitten mice was placed in large culture dishes along with the scent of unbitten mice. In this way, the researchers could test the snake's reaction. The vipers made a clear distinction between the two kinds of scent, and that of the bitten mice had an especially stimulating effect on the viper's search motions. Biologists take this to mean that the mouse's epidermal glands are activated by the bite, and that the scent subsequently given off differs a great deal from the mouse's usual characteristic scent. After a brief pursuit of this special scent, the snake naturally finds the dying mouse and devours it. The act of devouring is a different one from that of biting. The venom fangs which previously were put forward are not now exposed. Thus, "biting" is not always the same thing for the venomous snake. There are two kinds of "biting": One devours and the other envenoms. The entire cycle of its behavior and the effect of stimulation which guides the behavior is laid down hereditarily in the snake's form of being.

It was precisely the inhuman strangeness of this pre-arranged relationship between prey and hunter which moved me to choose this example, an example that will seem grisly to some. The appearances of nature provide a rich mine from which we take our poetic images, and everyday wishful thinking seduces one all too easily into a choice of images which are apt to dwell especially on the idyllic. However, a conference which has as its theme the sympathy of all things should not end in idyll. The strangeness and darkness of the things in the world are too shocking and too oppressing. We therefore do not intend to conclude our conference by taking up the light, joyful images of the search for blossoms by hummingbirds or bees or butterflies -- all images which come to mind so easily! Rather, we mean to enter into the gloomy realm of the viper where, through hereditary innate modes of behavior, one animal is preordained as prey, another as hunter.

In light of these kinds of prearranged relationships, we perhaps have a better understanding of the lapses of some thinkers into the notion that even the animal world is, in its own peculiar way, caught up in original sin, and

thus is need of a final redemption. Here the biologist's powers are limited, at least to the extent that, with all due gravity, he continually and emphatically points to these strange modes of living existences in order to help us experience the monstrous primordial foundations of the most hidden workings of things in all their darkness. It is, of course, in order to promote a large notion of the workings of things that we, right here in the Eranos-circle, take such pains on behalf of the grasp of nature characteristic of the Far East. For, that grasp is in many ways closely allied to the view demanded here of investigation into life.

We humans are permanently Ptolemaics in the way we sense. The prearranged relationship of our experience of the world is earth-bound; it knows neither of the Copernican solar-system nor of the worlds of astronomers. But, through the special openness peculiar to the way humans experience the world -- and this may well be our most significant peculiarity -- the possibility has still been prearranged for this Ptolemaic man to leave this earth's surface in thought, and to undertake far-reaching journeys which will lead him to an entirely new world-view. Every Eranos conference is a mobilization and prearrangement for such a journey. And, if our gathering has been a good one, we, better equipped for that journey and with a clear vision of it, can take leave of one another once again.

CHAPTER II
Endnotes

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PART II

THE EXPANDED SCIENCE OF LIVING BEINGS

Introduction

In this section, we will be introduced to some of the details of Portmann's views on the necessity to modify certain presuppositions of his fellow researchers in the life-sciences. First, and perhaps foremost among these is their refusal to consider what Portmann calls the "self" or "inwardness" of the living being. In his view, the self of the living being is, above all others, the prime subject-matter of any complete biological science. Consequently, those metabolic systems studied, to the exclusion of any other aspect of the living individual, by biophysics and biochemistry as including all that biology *should* study are, at best, only ancillary to what they support -- namely, the essentially self-differentiating, self-expressive individual.

We now proceed by presenting essays of Portmann's which address both the proper subject-matter of biology, as he envisages it, and the way in which contemporary biological research must be modified to permit it to address this subject-matter -- i.e., Portmann's critical analysis of contemporary biological science and his own correctives.

CHAPTER III

PROBLEM OF LIVING THINGS[1]

I
Matter and Psyche

Among those appearances which we find most familiar, it is the living things which show us the polarity of the material and the "psychic" -- taking that term in the general sense of the spiritual-cognitive-psychological rather than in any theological one. We know the psychic realm best from our individual experience. Consequently, the further any given organism is from our form of life, the more unsure any of our pronouncements concerning this hidden inner being will be for us. This situation posed the question of access into the inner world of living beings to natural scientists, and they long ago answered the challenge with this radical answer: the task of fathoming the material world was to be assigned to physics, with the provision that it must exclude from its sphere of interest and attention the barely perceived and little known facts concerning both the experience belonging to and the richly meaningful behavior characteristic of organisms. But we today are faced with such a highly developed behavioral science that biology no longer can accede to these limitations with their original simplifications.

If we seek to comprehend life where it appears most simply in its form and function, as, for instance, in viral material, we will thereby reduce the well-known characteristics of living things to a few criteria such as the replication of the hereditary substance in the virus-specific nucleic acids. The great significance of these findings for the progress of the biochemical research endeavor will be contested by no one. However, when it has been simplified to this extent, such a picture is only of value as a model for a narrow section of living things. The edifice of biology has not been established on the foundation of limit cases -- neither on the basis of the simplest living material nor on that found in the highest spiritual functions.

Rather, biology has been built up on the investigation of the abundance to be found in a middle range where plant and animal life are represented -- and this includes our own existence.

The natural scientist who has made it his task to penetrate the material world can disregard the psychical phenomena in many of the formulations of his questions, and he will do this with so much the less hesitation the further the object of his undivided attention is removed from our own degree of organization. Botany, therefore, was singled out from the great original association of biological disciplines because many of the procedures of its researchers can use the methods of physics and chemistry far more extensively than is the case in zoology. Plant science permits very many of its practitioners to disregard with light hearts that side of living things which involves their own experiences. But what we must remember is that the use of scientific means to fathom those aspects of living things which are exemplified in plants comprises a genuine "disregarding", a renunciation. Although we no longer speak or write of the "soul-life of plants", as G. Th. Fechner could and did in 1848, we should still be aware that plant life is more than we can express if we only use those instruments designed to investigate the material world.

Developments in zoological work have been imposed upon psychological investigations with striking force. Behavioral studies can use their important methodological clarifications to grasp the hotly contested problem of animal psychology with new means. This is now possible because of the new paths along which they developed during the last decade. These studies have shown us that there exists a way to make assertions about the inner condition of an animal, and hence about the motives for its actions, but starting from its behavior -- and therefore we see that not only can we enlarge our description of these aspects of living things, but that such an enlargement is both possible and necessary for natural science. This enlargement may well be considered as one of the most significant biological advances of recent times. It ranks with the great discoveries in the realm of the material world and with that of genetics and the physiology of metabolism.

We are here speaking about a new form of animal psychology. However, we do not wish to forget thereby that, beginning with bare matter and continuing on up, the unity of living things is so strikingly attested to that we may not restrict the facts of our daily experience to any one part of the plenitude of the living. Even if the possibilities for asserting anything about this other side of living which is exemplified by the realm of plants and the simplest organisms are very meager, it is none the less necessary for an investigation which lays claim to a comprehensive orientation to have, as really present to it, even what is seen -- at least in our current thinking about organisms -- as hardly accessible to it. A researcher of William Roux's orientation insisted upon this necessity, even though he emphatically stressed the methods of physical chemistry as the proper path for work even in biology. The founder of the series, *Archives for Developmental Mechanics*, (*Archivs für Entwicklungs-Mechanik*), expressly emphasized that all characterizations of living things, such as metabolism, reproduction, irritability, etc., were insufficient designations, and that to be correct they should be labeled properly with the prefix, "self". In names such as self-development, self-metabolism, etc., the importance of the relative autonomy of the living processes is presented first; and, even if we seldom use these complicated expressions because we prefer a simpler expression, they must always and in all cases still be tacitly presupposed in our reflections concerning living things.

The study of plant life will also make us aware that the many-sided answers which plants reveal to us concerning the question of sensitivity can only be grasped as a part of a larger whole if we admit that plants also possess one of the fundamental properties of living things: the subject-nature. We see plant life as an actively operating subject inside its environment, even if we must view its capabilities for acting as being much narrower than those with which we meet in animals. It is presently taken as self-evident that our idea of the subject-nature of living things may not be restricted to phenomena involving consciousness for the simple reason that this question of consciousness must surely be pushed into the background even in the representation of animal behavior. Whether consciousness is present in animals is no longer contested; how widely it is to be found and how its presence can be demonstrated is another problem.

The very existence of two poles which we must consider that of the material and that of the psychic-subjective brings to light the breadth as well as the difficulty of every investigation of living things. However, whereas the technique of quantification and the mathematical treatment of results within the domain of the investigation of the material have produced their especially great and celebrated yields, we, on our part, enter into a world from the side of the psychical, into a world in which very little is to be gained by the use of quantitative methods. Although we most certainly do not consider measures and numbers as worthless for psychological investigations, still, the realm of qualities, and therefore the realm of subjective appearances, implies a world in which quantitative conclusions are not sufficient. This is a world where past and future are present and actual in experience, in which, as it turns out, an experience of time is possible for dreaming men which can be distinguished completely from that world experienced in daily wakefulness. Concerning this, Heracleitus long ago hinted that whereas our conscious experience places us in a cosmos which is common to other living beings, when we sleep we return to a private world of another kind. No one may exclude this enigmatic way of existence, (which surely occurs in higher animals other than men as well), from the consideration of biology, and we must at the same time admit that it cannot be properly investigated if we only use the tools presented by the routines of physical chemistry. The physician, whose work engages him with the most complex living structures which are accessible to us, must, more than any other scientist, keep this double aspect of biological work in view, and he must act accordingly in his daily practice. Great advances in medical research rest on the methods of natural science, especially on the direct application of the procedures involving the use of chemistry. However, developments which have been taking place for almost a century give evidence of the necessity for the double aspect of research concerning living things. It is one of the great tasks of medical research, with its ever-increasing mass of results which it gains from investigation of facets of conscious experience, to make these results fruitful for the solution of problems dealt with by the medical practitioner.

II. The Various Grades of Living Things

The forms we call organisms are beings which present us with organs which are formed to accomplish definite tasks -- be these organs only the roots, leaves, flowers and fruits of plants, or in the case of animals, the organs of digestion, or breathing, or circulation and excretion, or the instruments by means of which we move, see and hear, or even the instruments of neural and hormonal control. Since time immemorial, we have grasped the living entity as the association of a totality comprised of organs[2] which we understand functionally by analogy with our human technology. The model of the division of labor in human society and our human use of tools both provided us with our initial concept of the organization of living beings. Then, this insight into the harmonious functioning of the organs[3] of living things led us to transform the organism into a model for the social division of labor in human political bodies. However, with the discovery of the microscope and the use of physical and chemical procedures, another very different world of forms came to be seen. For at this point we begin to meet with what is properly the formative material of life, protoplasm: Structures became visible which we can no longer grasp with the concepts taken from our ordinary experience of technology. Our discovery of the existence of these structures leads us into the zone of molecular and atomic processes and the investigation of these areas has led to an extraordinary expansion of biological thinking. Now, for the first time, we have pushed our inquiries into the region of "elementary" life-functions.

If, for example, I speak of breathing in the course of ordinary conversation, I think about breathing in and out, about the activity of our lungs, or about the gills of fish. But, if I ask the biochemist about this process, he will refer to breathing "properly speaking", that is, to processes which, with the help of fermentation, insure the regular acquisition and disposal of our energy in the realm of protoplasmic events. Whether we investigate nourishment or excretion or the use of our senses or motion, we constantly meet with complements: the plasmatic structures are seen as

being coordinate to the skeletal-muscular apparatus which works following the law of the lever, and it is in the skeletal-muscular apparatus that we have events presupposing bones -- that is, events like muscular contraction. The study of our eyes which can be grasped using the model of photographic apparatus requires me to expand my study of that mechanical apparatus to include the processes in the neural tissues if I wish to come closer to a real understanding of seeing. But that last study is much more difficult to grasp than the processes found in the photographic apparatus. Among the unforeseeable forms under which the propagation of organisms presents itself, the investigator into nature discovers the sphere of plasma events. This sphere comprises a splendid unity in plants and in animals.

Biological work must separate these two spheres from one another and try to recognize that each has canons proper to it. In what follows, therefore, we shall sometimes speak of two levels which, for the sake of simplification, I shall call the "macromolecular" and the "instrumental". Today, the macromolecular has gained the attention of the larger part of the research community; molecular biology is a field which draws more and more of the most recent generation of biologists under its spell.

When we discuss things in this realm, we are tempted to speak of the simplest living matter. But this simplicity is an illusion. The living matter which appears empty to us within the limitations of the vision afforded to us by the light microscope nevertheless shows us new and complicated structures when we view it under the electron microscope. Furthermore, the methods used by chemists and physicists produce results which strongly suggest that beyond the range of visibility there exist a high degree of complication. This sphere of living phenomena not only draws those researchers who seek a deeper understanding under its spell; for here the possibility of domination over living matter entices the researchers as well. A world to be grabbed presents itself.

The macromolecular level is distinguished above all else by the fact that, in it, we do not find that operational mode which makes understanding of an organism possible from our ordinary way of thinking or, if we are able to do so, it is only partially. The study of living matter leads us immediately to other processes which rest on the relationships of atoms and molecules

and here we have to deal with chemical valences and physical operations. We are being led to an event *which makes possible* the instrumental processes we usually meet within the sphere of daily experience. On that level, we look for the molecular laws of muscle contraction or of enzyme action, for the molecular laws governing the processes which terminate in the nerves and, finally, for those laws on which our relation to the world is based.

The macromolecular level is where we find that the fundamental phenomenon of living things which we label as self-increase in living matter, i.e., as duplication, plays its role. It is also in this zone that mutation occurs, where we find the hereditary changes of structural elements which are reproduced from one generation to another in the process of generation.

Molecular biology and microbiology are not far from comprehending the special processes of duplication for the different structures in the cell nucleus and the cytoplasm. The self increase of giant molecules--among others, of DNA in the nucleus -- has drawn special attention to itself because these molecules are the carriers of hereditary events.

The proof of the existence of special nucleic acids in the cell nucleus by Fr. Miescher, (in 1871), has been extended recently to include the discovery of structures, especially of DNA, whose material-ordering permits the storage of very complicated "blue-prints". We have learned to recognize other materials which "read" such blue-prints and which, by means of further events taking place in the plasma, convert them into new forms. This information-storage capacity brings to light a whole new quality of matter in living things, a quality which we cannot measure in units of energy or force, but only with the units of Information Theory. It is one of the great tasks of molecular biology to investigate these processes and to grasp them firmly.

The unity of living things has been uncovered in a splendid way through the investigation of the macromolecular level of living matter. The breadth of distribution of ribonucleic acid and other elementary structures in the plasma of animals and plants, as well as in bacteria and viral material; the structure of cells in both domains; the identity of enzyme activity; the identity of hereditary events and of sexual phenomena: all these are results of work which, within a few decades of one another, have contributed most essentially to the building of a new research edifice, that of a "General Biology."

What is more, all growth of organisms, all increase, goes back to the elementary events found in the molecular domain. One of the marks characteristic of this level is, on the one hand, the maintenance of a definite size of living structure which is conformable to a given species, and, on the other, the increase in the number of the living individuals through division -- where the self-increasing elements sometimes are reproduced as two sister structures. This capacity for increase and division leads to a situation which separates the macromolecular domain of events from the instrumental level of living matter in an especially striking way.

Are we permitted to compare the results of these continuous divisions with the *individuals* belonging to the higher levels of organization?

We would do much better to reserve the concept of the individual for the higher and we must stress as a characteristic of the lower, macromolecular, level of life, precisely the lack of individuality. In agreement with this, we also must stress that in this life-sphere there is no genuine death. Indeed, organisms on the macromolecular level can perish as distinct beings because of mechanical annihilation -- for example, through being eaten. However, this happens because of an active, foreign, destructive power outside their own being. This "perishing" is not the "death" of the higher live beings. Much has been said of the "immortality" of the proteins; but that word, "immortality", obtains within a sphere in which there are true individuals and in which the death of distinct beings poses special questions to us humans. The genuine individual and death, properly speaking, are the marks of a higher level of living. The individual and his death -- that is one of our primal experiences whose problematic aspect has been considered in religious and philosophic thought long before any science, and this experience has been resolved differently by different kinds of belief. These questions do not arise in the investigation of the macromolecular level of living.

More exact examination is needed if we are to determine just how much more sharply we can distinguish the limits separating the macromolecular from the instrumental level. Within the range of electron microscopic visibility and even in the order of magnitude which is still barely accessible to light microscopy, the macromolecular order builds structures of

a higher kind. These constructs have been called "organelles" to distinguish them from organs properly speaking. At present, electron microscopy is developing its techniques through its intensive researches concerning these objects. To name a few of them, we have the mitochondria, the endoplastic reticulum, (with or without ribosomes), the carriers of chlorophyll, (the chloroplasts), fibrils and vacuole-structures and, as the most striking of these structures, the chromosomes along with the cell nuclei.

From the very beginning, the basis for defining such plasma organelles as standing in opposition to the organs of the instrumental domain was to be found in the character of their functions. The living organs work in the realm of macrophysical conformity to natural laws, and the macromolecular structures are subordinate to other conditions. The unified whole formed out of the instrumental structures rests on the macromolecular order. Indeed, the activity of the locomotive apparatus can be understood according to the laws of the lever and other such macrophysical operations. Nevertheless, at the foundation of the essential process, the contraction of fibers, lies another event belonging to the macromolecular sphere. The case is similar for nourishment derived from food, where its acquisition, chewing up, and even its transport into the digestive tract all follow the laws of classical physics, while the actual processes of assimilation on the level of glandular activity and of the reabsorbing mucosa must be imputed to the play of macromolecular rules. Likewise, all these developmental events which finally produce the higher organism and which builds up its organs take place in the domain of the macromolecular.

There are good reasons for us to stress this separation. On the one hand, the research methods and goals for the two realms differ while, on the other hand, the work in each field constitutes a persisting task for biological research. The point of view that investigation on the macromolecular plane should be considered the work proper to biology simply overlooks the fact that beyond that level, the instrumental stage requires other methods and sets us for itself other goals. Morphology, especially in its comparative approach; paleontology, which is so essential for research concerned with evolution; ecology, which inquires into the relation of organisms to their environments; and, finally, the flourishing research into behavior, which

inwardness because that notion of world relation points to many possibilities of objective determination through scientific means such as, for instance, the physiology of the sense organs and the nervous system, as well as the study of all the working organs, of the muscles, glands, etc. But, included in the concept of world relation are both the fact of the individual precepts of the environment, (hardly accessible to our research), and the accompanying experience of that environment; these must be faced, even in all those cases in which such individual percepts are merely suspected but cannot be characterized more definitely. Membership in a world relation makes possible a more or less rich inner world about which we can assert nothing definite, in the case of plants, but about which we are becoming increasingly knowledgeable in our investigations concerning animal life. As we have already said, when we pose the problem in this way, the question of consciousness remains open without thereby blocking access into the investigation of the subject nature.

I place this characteristic sign of the organic, the world relation, in the foreground within the context of a consideration of metabolism. I do this because, from this point of view, metabolism turns out to be a partner in the maintenance of the relatively autonomous system, of the subject. We are investigating a closed circle; living substance as presupposition for metabolism and metabolism as condition for the maintenance of living. I can arbitrarily pick out a point on this circle as the beginning and then investigate causal sequences of events from that starting point; nevertheless, I must always think back on the totality of the system and never lose sight of the fact that all results of causal investigations are qualified by their adjustment to this pre-given system whose laws lie beyond the causal fathoming of individual processes. The pregivenness of this *unity* of systems becomes obscured during analytical investigations which we initially undertook so that we could so much the better direct our attention to the processes which belong to a *part* -- and thus it is so much the more necessary to direct our glance back to the system within which the analyzed part was previously found.

Researchers in general biology often advance metabolism as one of the most significant characteristics of living things. Such preeminence primarily rests on the fact that these processes can be grasped precisely using the means available to the laboratory techniques of physical chemistry. However, it is at exactly this point, (where I do not permit myself to make assertions concerning the inner realm of an organism), that the processes of metabolism can be laid bare. What is more, these processes reveal to us an astonishing identity of fundamental processes in all forms of life. However, there is a deep desire on the part of the biological researcher, which has no little place in his decision to award such a preeminent role to metabolic processes: the will to master those processes and the potential to intervene in and gain control over natural processes in general.

If we disregard these important grounds for stressing metabolic processes, other essential characteristics of living things, such as temporality, shape and its transformation can certainly be very much placed in the foreground as well. The role of researches into metabolic processes is primarily dominant where man must intervene, and it is therefore entirely understandable that this aspect of biology must occupy a place of great importance in medicine. However, this pragmatic point of view should not be permitted to obscure the fact that in the final analysis, these processes serve the maintenance of a system which is more meaningful and has a higher rank due to it than can be given it by investigation of the processes studied by biochemistry. The development of the ability to penetrate down to the mechanisms of metabolism and the accompanying economic role which we today give to the industrial side of this research have both allowed us -- only temporarily, it is to be hoped -- to forget the proper hierarchy of living processes. Biotechnics, which daily increases in size, and which is today already a world power, can, perhaps, temporarily reinforce the view that living things comprise just that with which metabolism is concerned. It is so much the more necessary that the biologist be reminded that he must become aware of the orders of forms which are based on life itself.

IV
The Question of Origins

In very few areas of biological research has the change in our thinking -- because of research into the macromolecular level of life -- been so striking as in our views concerning the problem of origins. In pre-scientific times, even in the west, all reflection concerning the beginning of the world and life was the product of an imagination which drew its nourishment from everyday thinking. Before profound investigations demonstrated that all living things presupposed a pre-formed seed, egg, and sperm, it seemed quite possible and in agreement with naive intuition that organisms could arise from muddy water, from mud and filth. This was a time which knew nothing of the causes of infectious diseases, where there were still regions in which the "air" was unsound; "mal-aria!" places with mysterious miasmas were identified as occasion for all sorts of diseases. Abiotic generation and spontaneous generation of living things appeared as natural phenomena. Louis Pasteur's discovery that even the simplest life forms such as bacteria could be derived only from specific germinal agents gave an entirely new turn to the problem of living things. That problem was addressed subsequently, beginning with a question as to how the earliest form of living things had been constructed out of the non-living, and therefore out of the inorganic. Was this a unique happening in the remote primal times or does it happen yet today?

The supposition of such an event was a development which arose out of the demands of evolutionary theory, and many of its advocates indicated their rejection of the notion that abiotic generation in fact comprised a relapse into belief in miracles. On the other hand, however, even in the early period of Darwinism, it happened that exactly this assumption of abiotic generation appeared as comprising a recourse to antiquated wonder-mongering. It appeared so in light of the idea of the cosmic origin of life, of the idea that life always has been at hand in some sort of seminal form, and that it still is. The old war against the doctrine of creation as it was found in Christianity also played a role in these disagreements. Darwin, who had dealt the most severe blow to that creationalist thinking in his work of 1859,

could not help but insert a conciliatory sentence in that very same *magnum opus*: life might have been inspired originally by the Creator in a very few or even in one single living being! That Darwin wished primarily somewhat to conciliate his all-too watchful opposition with this formula is certain, and it is thus also not surprising that his first translator, H. G. Bronn, censured the inconsistency of that statement as early as in 1860. Louis Pasteur, who himself had provided the demonstration that even the simplest life forms only arise out of already existent germs, characterized the origin of life as an impenetrable mystery. Until as late as the 20's of this century, biological textbooks mirrored this twofold division in the attitude of science towards the question of origins.

In the third decade of our own century, however, the point of view of the researcher into questions concerning abiotic generation changed in a decisive way. Assays into the field of viral material produced a model of the primary level of living substance. Although the fact has always been noted that such viral material only increases itself in the company of already existent life and that this shows essential characteristics of being alive only there, still, scientific thinking concerning the primary level of organic structures entered onto a new path. Although these viral substances *of today* can thrive only on already living foundations, the idea was developed that the external conditions could have been very different in a far removed period of terrestrial history. This was the beginning of a rising interest in the essential conditions for the origin of life on the Earth's surface -- an interest which required that biochemists, physicists and geologists come together and work as a team. As early as in 1924, Becquerel stressed the possible role of ultraviolet rays in biopoesis--i.e., in the process which originates organic matter. In that same year, the Russian researcher, Oparin, sought in a world without life for the precursors of protein materials. He searched for the possible construction of the simplest hydrocarbons. In agreement with Oparin, Haldane asserted in 1929 that prior to the emergence of life, methane could be present in the atmosphere. More and more, evidence for the possibility of precursors of living things, i.e., of proto-vital macromolecules, became apparent.

Since the 1930's, and accelerating anew after the Second World War, astrophysicists and biochemists led a new way of thinking about origins which was the beginning of a many-sided empirical investigation of the subject.

plant and animal life is captured in the figure of a circle. The green plants -- which are the foundation of all higher life in this picture -- enable the carbon dioxide of air, (or water, as the case may be), to change into organic substance with the help of chlorophyll. By means of this process, plants give off oxygen which benefits the animals. Through their breathing, the animals supply carbon dioxide to atmosphere, (or to water), and thus they supply an important end-product to plant life. This particular way of viewing the matter has confirmed a common concept of great antiquity which sees in plant life the necessary condition for animal existence and thereby also takes for granted that it led the way in development of organic life. This sketch we have just seen concerning concepts of the origin of proto-vital substances forces us to think again about the matter. Carbon dioxide and oxygen are lacking in the presumed original atmosphere. Indeed, that is a central presupposition of those investigators of origins who have striven after the formation of proto-vital substances completely independent of carbon dioxide and oxygen; and now they have also confirmed their suppositions through their experiments.

The notions which are developed on such foundations concerning the beginning of life posit a proto-vital material as well as an early, properly living, material -- for which the "classical" cycles of carbon dioxide and oxygen do not play a role!. This absolutely primitive life in no way has a plant-like, nor, properly speaking, an animal-like character if we infer these characteristics of the two realms from present-day life forms. An atmosphere in which the formation of organic substance through assimilation of carbon dioxide becomes possible is a late phase of the events taking place on the surface of the Earth and is already a consequence of existing life. It is during this late geological situation what we imagine the origin of complex living plasma structures which we know as chloroplasts, carriers of leaf-green, from which the transformation of inorganic matter into organic was performed. Structures such as the carriers of leaf-green are therefore relatively late products of an already far advanced evolution of living things.

We will not minimize these considerations, leading us, as they do, deeply into primary facts concerning life which we have difficulty conceiving as the final knowledge we are able to gain from our investigations; to the contrary, they reveal how once deeply trusted fundamental presuppositions

concerning interconnections between living things have most recently changed. Researchers must remain wide open to similar revolutions in thinking which are still in store for us.

First of all, let us keep firmly in mind the idea that the first stages of living can be called neither plants nor animals but, rather, that they directed their mode of food acquisition to already present organic substance which was not itself dependent on the "living", where this latter substance, in its turn, arose out of inorganic foundations -- and so no longer arises under the natural conditions of today's Earth. Those biochemists who insist on a certain family resemblance between the blood pigment of animals and the green in leaves also consider the possibility that the respiratory pigment of animals could have preceded the formation of leaf-green during the course of the Earth's history. We will entertain even this hypothesis, merely as evidence of the transformation of presuppositions of very long standing. Thinking concerning the origin of life has entered into a new phase because we have used experiments to investigate it.

Since those researches began to bear fruit, discussion has been concentrated on the question as to the minimal requirements we must place on a first "living being", and thus on a system which has progressed beyond the proto-vital stage. One such system -- already comprising an advanced molecular structure -- which maintains and reproduces itself in the interchange of materials with its environment because of some peculiarity in its system, must close off the self-reproductive component of its system from the outside in an open way. A boundary membrane thereby becomes an important organ of the simplest organism. It is active in two directions, namely, "in enclosing-fending-off *against* the environment and in unlocking-mediating *towards* it," (Plessner, 1965). It is its mediating surface which locates a body in relation to its medium and that surface therefore does more than merely bound it. The fact of this bounding membrane, of this "skin", poses problems -- namely, the problem of specific form, the problem of irritability, the problem of behavior -- and thereby, finally, the question concerning inwardness, concerning a self and its self-preservation. Which method of investigation into nature will give an answer to these questions and what importance such questions will have are problems which natural science and philosophy share as a common concern.

The search for the simplest living structures will also bring us to the quite complicated relationships of these early organisms to their environment. Hence, it might be well to bring this survey of questions concerning origins to a close by touching upon a property such as the response of the living being to the Earth's daily rotation and thus to the terrestrial day, and to point out that this property does not only belong to the higher plants and animals. Rather, it is already a property of the unicellular living beings. The structures which make this much discussed "inner clock" possible and its adaptation to changing external conditions are judged today to be fundamental properties of the protoplasm, and it is perhaps possible that they had been formed during very early primitive conditions of marine living, with its change of day and night and of ebb and flow. The fact of a widely distributed inner rhythm of approximately 24 hours for the synthesis of materials, mitotic cell divisions, nervous regulations and the like, can perhaps also be used as an argument in favor of the origin of life in tropical waters.

V
Evolution

The change in thinking concerning origins is closely associated with the weight given to the theory of evolution. As a leading theme of today's biological research, that theory rules over it. Discussions concerning the significance of theories of development -- and these discussions are still as lively as they ever were! -- also show that, along side the victory of this way of thinking, biological research has created a source of conflict in the West which is in strong agreement with that explanation which is characteristic of the East's world view. This conflict, it is perhaps worth noting, is exportable and enters into other cultures along with the dissemination of occidental technology.

We must remind ourselves of the fact that in its attempt to understand the problem of origins, evolutionary theory has cut us off from a concept of the organism which is in agreement with archaic forms of human thinking, forms which in the West had played a principal role, through the continuity of the doctrine of creation, until well into the 19th century. The living forms

appear as "creatures", in the deepest sense of that world as creations of an almighty spirit and hence understood by us in respect to their origin just to the extent that the divine act of creation can be understood by us humans. The re-constitution of this notion has a long history, and we must keep that history in plain view if we wish to understand the peculiar position of the theory of the descent of the species in the thought of our time. That history begins in our Western World with the destruction of the biblical reckoning of time, with a powerful forced entry of strange notions concerning the age of the Earth which, according to this view, far exceeded the few thousands of years which could be counted out of the biblical account. The 18th century already knew of millions of years of terrestrial history, and thus of notions which have been long current in other cultures.

The scientific inquiry into the stratification of rocks, and with this, a first rational determination of time, begins at this point. Also, the investigation of fossils as evidence of antediluvian life was intensively pursued and extended until it comprised a proof of the gradual formation of living forms in the course of the Earth's history. The role of Lamark, together with Darwin's entirely different role, are too well known to be given in detail here. It is perhaps more important to make clear that during the time in which Darwin produced his masterpiece of 1859 -- during the period spanning 1837 to 1858 -- thought concerning the idea of evolution already enjoyed a wide circulation. Darwin was especially effective in that he offered a comprehensive, rational explanation for the evolution of organisms which permitted scientists to see the unfolding of life-forms as the product of chance, inherited variations and of strict laws of natural selection. It is *this* aspect of his contribution to the widely received theory of evolution current at his time which shook one of the foundations of the Western World view, and which thereby also pre-empted the religious, social and political fabric of our part of the world during the second half of the past century. Anyone who does not take this side of the theory of the descent of the species very seriously cannot understand the shock whose secondary waves we are still experiencing -- and which sometimes places obstacles in the path leading to an objective, factual assessment of scientific discoveries.

It will be our first task to give a picture of the fundamentals of contemporary thinking which regulates science, and thereby at least to pose the problem of the extent, the borderlines as it were, of a theory which is the guide for much of our thinking in biology.

The examination of living forms, be these of plants, animals, bacteria or yet simpler examples, forces upon the investigator the idea that this rich manifold has been unfolding slowly in the course of the evolution of the Earth, and that this terrestrial evolution has taken, according to present ideas, about two billion years or, according to the very latest discoveries, in the neighborhood of 3 billion years. About one half billion years of this period is clearly represented in fossil remains of plants and animal life. It is the consequences of this last geological period with respect to the biological forms arising during it which have made the concept of the gradual evolution of the organic world into a catch-word for investigators. This widely held view forces one to think about the precedents of the transformations. For now, however, that period only gives us some results, for instance, in its picture of the "metamorphosis of types", *without* including the hidden play of force which has brought this metamorphosis about.

Newer investigations, however -- and herein lies the great achievement of Charles Darwin -- attacked these questions. Alexander von Humbolt who, before Darwin, had attempted a unique and vast world-picture with his *Cosmos* of 1843, considered that the question of genesis lay beyond human experience and thus that it was not to be discussed by research. We have seen, in the example of the origin of life, how greatly things have changed in this respect. The investigation of the transformation of living forms is fully under way. For some time, shortly after the end of the last century, it appeared that the new research into heredity which had developed after the rediscovery of the Mendelian laws of inheritance placed many of the foundations of Darwin's ideas into question. What at this time was primarily the concern of these Mendelian investigations into hereditary processes, turned out instead to be, in a most impressive way, the study of precisely the activity of those factors *on* which the preservation, i.e., the constancy of organization, depended. The original investigation into heredity led to conservative procedures in thinking, and that investigation was even

opposed, in the public discussions of the first decades of our century, as being a retrograde impulse working against the overwhelming acceptance of Darwinism.

However this may be, the elements which revealed the revolutionary side of hereditary events were discovered precisely in the most central of the fields of endeavor correlated with this conservative investigation of inheritance. The first inherited random variations were discovered in the laboratory during the year 1909 and at this point such "mutations" in plants and animals began to be investigated more exactly. 1927 saw such kinds of persisting variations successfully induced through radiation and we also knew of the possibility of chemically induced inherited changes by the beginning of the Second World War. While the experimental investigations of mutations in laboratories were gradually moving forward in the direction of a new theory of evolution, the indepth investigation of mutational action in larger groups or organisms was also beginning. Population genetics directed attention away from the individual to phenomena of groups. It showed that the inheritance of animal and plant characteristics must be studied and critically examined within this wider framework. And so, with many echoes of and points in common with the earlier Darwinism, a new theory of evolution was then formed. This has come to be designated as "neo-Darwinism", while other investigators hoped for a quieter, but more enduring, result when the new creation was named the "synthetic theory of evolution" -- as if original Darwinism were not already a synthetic concept! It seems to me more correct to speak of today's form as a "general theory of evolution"; this is the form largely accepted presently, and it is likely to be the one accepted for the foreseeable future. Then we can designate the most recent special evolutionary theory concerning mutational factors as "neo-Darwinism."

The most significant advance of this new theory over earlier Darwinism lies in its ability to shed light on the raw material on which a selection process could work effectively. Darwin had seen this material in the variations which all living beings produced as already existing in the seed, and it is these variations in that seminal material which permitted the descendants of individual parents, and thus also the descendants of a population, to deviate more and more, in the most diversified directions, from a middle norm, and thereby to provide material upon which the

selective process could work. The variations, as Darwin knew them, include, however, non-particularized as well as inherited variations which would later be characterized as "mutations", together with non-inherited "modifications" -- where these are not the cause of any change in the shape of the species. The demonstration of inherited variation which the new genetics gave us, i.e., the demonstration of the different kinds of mutations and reshuffling of what is inherited, ("recombination"), makes us sure that we have an initial set of circumstances of such a sort that selective processes can be effective if they start out from it.

A further advance beyond early Darwinism was made through the clarification of the concept of selection. Darwin himself time and time again stressed how much such expressions as "struggle for existence", "survival of the fittest", or "selection" must be taken as mere figures of speech for processes, and that they had almost nothing to do with events to which we refer with the words, "struggle for existence". As a consequence of this, one speaks today of the survival value of a characteristic or of its selective worth and also assigns great importance to this third factor -- namely, to the isolation of definite types which are more favorable to selection, an isolation which produces its effects, among other ways, through spatial separation or through temporal division of the reproductive acts, or, finally, by modes of behavior belonging to a given species. Population genetics has concerned itself intensively with the way in which inherited variations, selection and isolation interact.

No one doubts that selective processes and isolating processes are effective, although from case to case difficult questions arise as to the extent of these effects. On the other hand, there are widely differing opinions as to just how worthwhile mutation is as an explanation. We here address ourselves to the two poles of opinion in this exciting field, leaving out the middle grounds. In this survey, I am leaving out all those details which hitherto have divided evolutionary theory into opposed camps. Acceptance of the evolution of the organic world as a forerunner of self-differentiation of life within geological history is -- comprising as it does the theoretical heart of "general evolutionary theory" -- certainly a fundamental assumption of the contemporary investigation of living things. The arguments which are

opposed to it within scientific discussion can only be ones which criticize different views of the role of evolutionary factors -- but still within the framework of this general theory of evolution.

At one pole, we find the investigators who are convinced that these factors which we just listed as characterizing the special theory of evolution -- and thus of neo-Darwinism -- suffice as a rational explanation of evolutionary events in geological history. The phenomena of evolution appear in this way of looking at the matter as having been essentially explained, and it merely remains to complete fully the very large particular task which remains -- explaining the special course of events which took place in the different groups of organisms.

Around the second pole in this field of discussion we can collect all those biologists who are of the opinion that of course an ancillary role should be accorded to mutational events, but that the extent of its explanatory value ought not to be overly extended. It should be emphasized in this connection that the mutations which are known with certainty are events in the cell nucleus, and that to *these* certain events only a very insignificant group of exact facts can be correlated which concern the role of cell plasma in these processes. It should be remarked further that the mutations accessible to genetic research always represent strongly delineated processes in a stabilized, and thus harmonious, system, and that the long history of these complementary systems of plasma and nucleus cannot be grasped fully by the biology of today. The individual processes which we consider and control in the powerful way that science acts do not even suffice, in this light, to give us a satisfactory account of the origin of the simplest forms of life known today. And, finally, it ought not to be overlooked that to a large extent the neo-Darwinian theory of evolution establishes selection largely through sense-evidence -- and rightly so! (An unexceptional example of this is the role of pollination in the evolution of blossoms or the meaning of choice of food in selective processes.) On the other hand, we can never overlook the fact that, even in the face of the great successes of physiology and biochemical research, these very processes of sensation are to be reckoned as being among the great puzzles of living events -- no less now than they have always been! For one to bracket off the fact of inwardness and of experience as

being beyond scientific investigation is no solution. Precisely such a restriction stresses all the more that the search for scientific explanations can, *presently*, only determine one of these sections of natural events which are quite definite to our experience of the world. A complete explanation of the processes of evolution must also include just those facts which we experience in nature which we have just set aside -- such as, say, the origin of sense perception and the appearance of consciousness. These are facts of our inwardness to the opening up of which the new investigations of information theory also contribute important results.

VI
The Interpretation of Living Forms

If the scientific analysis of organisms is to know its limits, it must base its results on a working protocol whose methods provide valid results within clear definitions. However, at any given time, organisms are more than can be expressed scientifically.

As a consequence, the human spirit seeks an understanding of the world outside the definitions established by science, and, as it has always done, it still continuously oversteps these limitations. A first boundary line to be crossed is one which was established through the use of physical-chemical methods. These methods are sometimes designated, in a very narrow view of the domains involved, as the total realm of genuine scientific assertions. A second overstepping of bounds leads into a zone in which the assertive powers of research into nature are more modest, but in this zone the human spirit uses other forms of thinking to seek after insight into the interrelations of things we meet with in this world. Even the strict researcher of nature knows about these flights of thinking which sometimes indeed open, even to the most exact of investigators, unexpected glimpses into mysterious byways. This is most certainly *not* a case of suppressing spheres which lie outside the reach of natural science; rather, it is a matter of investigating carefully where the assertions of genuine investigation end. As the work of humans, all science is to be co-determined along with hunches and world views, and these anticipatory flights are detrimental to a genuine science only when those

spiritual powers work without being recognized for what they are, and they then grow out of proportion -- when, that is, the researcher who does not take note of their well-spring considers his own thinking as being ultimately completely objective, but that the thought of others is subjective and prejudiced.

In order to recall the variety of questions which arise here, questions which sooner or later always lead us to overstep the limits of the present-day scientific division of fields of investigation, it is perhaps not inappropriate to take a final glance around us and to choose, as an instance, the much elaborated problem of sexuality.[2]

Contemporary research into genetics is governed by the investigation into the processes which take place on the molecular level: the events in the cell nucleus and plasma concerning the replication of the elements of living matter, the relationships existing between the appearance of the mature sexual cells and the complementary events of fertilization; these are of such significance that for many investigators whose work is focused on these phenomena, the sexual problem must be solved on this plane and, as a consequence, it must be viewed to some extent as having its problems solved through this method of investigation. No one will contest the importance of these ways of investigation.

However, on the instrumental level of living things, the questions are of a completely different kind! Indeed, all the phenomena on the macromolecular level can just as well fit into a bisexual organization and therefore into an hermaphroditic construction -- and yet these same phenomena can also appear in the case of sexual dimorphism. The understanding of the hermaphroditic structure and of the spatial separation of the sexes must be sought in a direction which is totally different from that of the interpretation of the molecular processes. We are entering into the realm of ecological dependencies, but at the same time also into the realm of conscious relations of individuals to one another. We are here faced with the problem of structures which depend on their sense organs for the living together of the sexes. Facing the astonishing *unity* of fundamental phenomena on the macromolecular level is a no less astonishing *multiplicity* of the conscious world on the instrumental level with which the researcher must come to grips by means of his special methods. The temptation is

pole with its centers of the nervous system corresponds an increasingly formal marking of the generative pole. The marking of the head by means of hair growth and coloration, of horns and antlers and other skin structures has been long ago remarked; the richly suggestive formation of the anal pole has largely been excluded from morphological investigations. In the mirror-symmetries of the hoofed animals, in the rump marking of primates, in the placement of ornamental wreathing of hair and in contrasts of hair growth, that formation of the anal region often reveals an extreme degree of agreement with the formations found at the anterior pole of the animal.

It is uncontested that all these arrangements of the anterior as well as of the posterior pole can also assume the significance of role-carriers in the play of life, and therefore, that they achieve a functional worth and consequently a selective value. But this in no way explains their origin and, least of all, their continuation or enhancement. No one has tried to understand the progression of a testicle from the safety of the body cavity into the endangered position of the scrotum as an effect of selection. It is especially the beginnings of such a process which is especially opposed to all the usual attempts at explanation. I mention this phenomenon because it points us in the direction of complementary, harmonious currents in evolutionary events which, taken alone, cannot be evaluated as consequences of, but, at most, as secondary occasions for, selection.

The ornamental formation of both body poles in higher mammals is a phenomenon which, using the methods of morphology, can be demonstrated to involve interdependency of formal elements. In offering such a demonstration, we stand in a region whose assertions lie beyond those of the causal-analytical investigations of nature. Nevertheless, no one will deny to it the rank of a scientific assertion -- of an assertion, however, which certainly is of a different kind than those we can make within the field of causal-analytical work.

Our thoughts, however, overstep even these limits of scientific certainty. And so the attempt is underway to establish the relation of the just-mentioned polarity of form to a comprehensive polarity of individual and kind: the head pole appears as the highest formal manifestation of individual being -- the caudal pole, however, as the formal representation of the maintenance of species. With this coordination, the provenence of safe

scientific statements will be left behind. This does not in the least mean that in such explanations stringency of reflection and sobriety of examination will not call forth results which are significant for the formation of a picture of nature. We are within a quite wide field which is concerned with the enigma of living phenomena. And no one will misunderstand us when we say that the two-fold form of the sexes poses questions to us which point outward, over and beyond all the facts of the molecular level of living, beyond all merely functional explanations on the instrumental level. However, the answer to these questions also casts new light backwards on all levels of scientific interpretations of the sexual forms of plants and animals.

Scientific assertions occur in the context of a comprehensive attempt to understand the world around us -- to understand that world of which we are a part. The investigator knows about levels of meaning; he also sees the problems of living things in levels, each of which has its own special methods and its own possibilities.

CHAPTER III
Endnotes

1 "*Das Problem des Lebendiges*", *Handbuch der allgemeinen Pathologie*, (Berlin, Heidelberg, N.Y.; 1969), Erster Band, Ss. 187-204.

2 ["Sexuality" translates "Geschlectlichkeit" in the text. Portmann does not here use the term, "Sexualität" -- presumably because the root of "Geschlechtlichkeit" is "Geschlect" = "kind" or "species." The terms with "sex" as roots tend to stress the di-morphism of the species, the fact that their members are cut off from one another in their reproductive capacities. Whereas, the terms with "Geschlect" as roots tend to stress that what is taking place is a conjunction of like kinds.] (Trans. footnote.)

3 [Portmann here, as elsewhere, plays on the double meaning of *Werkzeuge* = tool; organ. In Greek, *organov* -- a tool -- was used by Aristotle precisely as Portmann uses *Werkzeuge*, i.e., also as meaning *organ*.] (Trans. footnote.)

CHAPTER IV
CONTEMPORARY BIOLOGICAL RESEARCH
Part I[1]
Cell and Plasma Research

Every facet of scientific research is motivated by two powerful incentives which leads us to reconstruct our view of life. For, on the one hand, new discoveries are forcing us to rethink old theories and to construct new, all encompassing ones; while, on the other hand, old modes of thought which used to be fruitful come to be exhausted and this sense of exhaustion impels us, without our being conscious of it, in the direction of new concepts. The character of scientific work of any given period is characterized by the combined influence of these impulses.

We shall here address ourselves to the way new concepts in today's science relate to research into the mysteries of life, that is, to the way they relate to biology. Let us first discuss the cell and its importance in the construction of an organism.

We constantly hear and read that all higher forms of life, plants as well as animals, consist of cells, of simple building blocks, as they are sometimes described, and we are told that these cells are the most basic living forms, each of which contains a little life-material or protoplasm, as well as a co-called cell nucleus. In this survey we shall attempt to grasp exactly how concepts relating to the cell's construction are being quietly reworked in modern research.

We first gained knowledge of cells with the invention of the microscope. One of the earliest microscopic discoveries led to the term "cell" so widely disseminated today. This discovery was that cork, wood, and other plant tissues almost all contain noticeable chambers under strong magnification. We did not realize until much later that such "cells", as they had been termed earlier, are only the hulls of the actual living material. The word "cell" is still being used, and that term for the housing is now being

applied to the constructor *and* to the inhabitant. Someone using that term "cell" today means the living plasma with its nucleus. Since about 1840, the view that all higher plants and animals consist of many such cells, indeed, of billions in the case of larger organisms, has been popular. The early laws of evolution which were first laid down in Darwin's master-work of 1859 gave new meaning to this theory. The fact that there are many plants and animals with only one cell nucleus -- we have come to term them, "unicellular" -- led to a daring overall view: these one-celled beings are considered to represent an early ontogenic, existential, step; that is, they appeared on earth *before* the many-celled creatures, and it is from them that higher plants and animals evolved, while an intermediate level was represented by looser cell-unions similar to colonies. According to this view, higher organisms should be comprehended as cell-states. Finally, the term "protozoa" -- or "first animal," "most basic creature," -- came into use for one-celled animal forms, a name which, it is worth reflecting on, expresses much more than the purely descriptive term, "one-celled." The term *first* animal represents a broad theoretical panorama and a statement concerning the most distant past in the earth's history. That term also implies answers to questions concerning creation which will most probably always remain one of the great mysteries facing research into nature.

But how does this basic assumption hold up today? Within a single century, cell research has managed to assemble a vast collection of facts resulting in an extraordinary widening of our knowledge of living things. Objective cell and tissue theories -- cytology and histology as the experts call them -- today form vital and strong members in the large organization of biology. But the theories concerning the *meaning* of cells now occupy a very different position. A significant, albeit rather hidden, change in biological thinking is taking place concerning these theories. We would here like to address this change.

Its starting point is represented by the theory of the cell-*state*. In very remote times, according to this theory, cells split off from one another during the course of their divisions, just as one-cell entities still do; however, these dividing cells later on began to remain together, and, finally, they comprised groups which also accepted the principle of sharing work. They assigned

each other different functions and became reproductive cells, sensory cells, muscular-glandular cells. In the struggle for survival, the more productive of these combinations always emerged as victors and gained the upper land. For this reason, more and more complicated organizational levels of higher animals and plants were developed. According to this view, it is the single cells which are *basic organisms*; they represent a case of *smallest individuals* which have given up their individuality in exchange for a life-furthering dependency. The question of how this unifying of the basic cells actually occurs, and what causes their separation of work and secures their cooperation is not answered by cell state theory.

In order to understand the change in thought quietly taking place today, we should be aware of the historical growth of this theory. About a century ago, scientists were confronted with the new, and at first sight strange, fact that higher organisms consist of cells. This was a fact that had to be understood. One basis on which it could be grasped was offered by the ancient analogy which compares the members of human society with our body's organs, and demands their harmonic interaction as essential to society.

The very availability of this analogy made it generally acceptable. Instead of organs, cells were now to be considered the final unit. The cells were termed citizens of a state, and it was said that these cells meaningfully distribute the different tasks of the organization of that state among themselves. In this way a term, "division of labor", which can only describe an observed fact outside a human situation, was brought forth as an explanation. Because of the growing education of large masses of people, this analogy of the organism with a state, whose individual citizens were cells, had become so widely accepted in a few decades that a mere hypothetical attempt to give a likely explanation emerged as a truth to be believed without any question.

Of course, the inevitable now occurred! The population growth in the modern state naturally makes any kind of classification increasingly difficult and, at the same time, all the more urgent. It must be imposed in some fashion. So, to accomplish this difficult and urgent task, the state reached, deeply and with growing frequency, into the big bag of biological concepts. And out of that bag it pulled, and continues to pull, the image of the organism as a cell state -- an invocation began thus to be heard which, as in

very ancient times, employed magic words: in the best of all possible states, the cells in the organism completely sacrifice their troublesome individuality for the sake of the whole, and the insightful citizen is, in precisely the same manner, meant to feel himself to be just another member of this totality. The goal has been achieved when he ecstatically experiences this giving up of individuality, this acceptance of service to the state, as the highest value in life. What we once used in order to gain a first foothold in the task of understanding the completely puzzling fact of cell-separation must, from now on, justify the totalitarian state -- as a scientific truth. This is indeed an evil logical circle of the most cruel consequences and research, although often unwittingly, has given the impetus for it, and, by the present time, an uncounted number of believers in this dogma of cell-state can be found -- human beings who believe that they now know all that needs to be known in the field which studies living things.[2]

In actual research, however, all this has a very different appearance. Occasionally, out of its quiet, something does indeed intrude itself into our noisy everyday life and demands our attention. But now we have become aware once more that the theory of the cell state was an attempt at an explanation, an attempt tied to its period; and we once again realize that the organism with its incredible structure still remains the great *puzzle* for science, posing new questions to every generation.

In order to see how the evolutionist approaches the question, let us look at one case history, that of the fly egg. Before the fly egg -- the subject of numerous experiments has definitely organized cells, one can already distinguish *organ-forming nucleus-areas* in the egg plasma to which very narrowly circumscribed activities can be assigned concerning the construction of the larva, the cocoon, and the fly. The fate of these areas in the egg nucleus has already been decided before the formation of the cells. They are *determined*, as the biologist would say, *before* any kind of articulation into cells occurs. The assignment of the plasma members to various functions of the organs therefore represents *one* process, while the sub-separation of the same plasma into small cells represents a second process. Both events cooperate in the construction of organs. The predetermined areas of the egg nucleus await the developing cell-nucleus -- that is, organ areas are not

articulated into cells until later. This means that these areas are not constructed by cells, nor pieced together out of building blocks or basic organisms. The mysterious plasma of the egg first articulates *itself* into the areas which will subsequently form an organ. The formation of the cells is another, additional, process whose meaning is yet to be explored. (Hundreds of such facts have been collected by experimenters.) Research concerned with probing the processes in the cell nucleus is once again making us aware of the importance of the early organizing processes within the protoplasm of the not yet differentiated egg nucleus.

Another example may serve to emphasize the importance of this evolutionary process -- *a process transcending any organization of the cell.* I take this example from the textbook on entomology by Professor Hermann Weber, published in 1955. In discussing the embryonic structure of the design on a butterfly's wing, Weber says:

> "It is introduced by a determinational flow which in its course determines the pattern-members. Nothing is known of the actual dissemination process, but the agents disseminating themselves within it are of a *trans*-cellular nature. This dissemination leads these agents to fill certain areas of the wing surface without consideration for the already present cell mosaic which appeared independently during the cell divisions."

Once again, therefore, the articulation of the cells represents *one* process, and events in the formation of the design apart from the cells represents *another* process -- both of which still need to be explored in all their properties.

While the concept of the cell state spreads a misleading semblance of understanding far beyond the range traversed by scientific research, the living plasma presents itself in actual investigative work as a still hidden *reality* which is yet to be explored, and it is the last functional entity to be completely understood by future research as a *reality* which, in the case of higher organisms, performs all functions of the cell and all the articulations found in the organism. One of the least noticed results of biology in our day is this retrospective indication of the actual research task still to be accomplished, a result which must be referred to if the more hidden path of things is to be revealed, and if it is truly our desire to participate in the continuing struggle for a new conceptualization of organisms.

Our linguistic usage is limited by the mighty constraint of habit -- as we see in biological statements where the terms "building block" or "structural element" slide off our tongues so easily as substitutes from the world "cell" -- even when the propriety of such a comparison has long been apparent to those with insight into the matter. The effort directed towards a renewal of concepts and terminology simply takes time.

In the reality grasped by a biology which proceeds by inferences from the phenomena, the cell is *one* of many possible modes in which living things are articulated, and, indeed, merely a particularly widely disseminated mode which is so widely found occurring because of instances in which the processes taking place *within the nucleus* are so important. It is for this reason that the exploration of nuclear structures developed into a new field of research -- especially since an important part of the reproductive substance is contained within the so-called chromosomes of the cell nucleus. We speak of nuclear physics -- giving a different meaning, of course, to the work *nucleus* -- and here we must, in a similar manner, make use of the term "nuclear biology". Alongside this tendency in biology, however, we find other researchers exploring the structure of the *plasma*, where this exploration also combines those new methods employed by biophysics, biochemistry, and bacteriology, together with the great usefulness of the electron microscope. I would like here to communicate to you the *purpose* which directs the investigation of the plasma -- where, naturally, this emphasis in importance always represents a personal point of view, that is, only one of several options. This new research developed a new order of magnitude even smaller than that which could be dealt with by the light microscope.

Much of its importance is connected with that fact. The image of cells as basic organisms has always been very strongly determined by the fact that any research is inevitably contained with the limits of the light microscope. Working within this order of magnitude, the cell represented the final circumscribed unit, richly filled with various substances, while its interior already presented an area which was difficult to approach. The methodological opportunities made possible by the electron microscope joined forces with the development of a special physical-chemical measurement, that of the "Great Molecule" or the macromolecule of more

than 1500 atoms. This area is, of course, not only vital to the comprehension of vital *processes*, but its exploration is also especially fertile because it gives new life to our concepts of living *structures*. Naturally, it has long been a well-known fact for cell researchers that they could *begin* their investigations of substantial living structures within the sight limitations of the light microscope. But introductory classes, as well as popularized presentation still present the general public with the following neat formulation: structures of higher forms of life are built up out of cells or cell divisions. Like children, we first construct all kinds of structures with the elements of our *construction* set; in the same way, our all-simplifying thought process constructs the more complicated of the living structures using cells as building blocks. Since some degree of simplification is required in teaching no less than in the popularization of science, it appears all the more urgent that the present search for more easily understood models should concentrate on the new size gradation extending beyond the usual microscopic limits, and thus seek to free itself from outdated views. As soon as we have succeeded in transferring our attention to the area of macromolecules, the many structures which, even within the sight capabilities of the common microscope were of a non-cellular kind, will suddenly gain new meaning. Such structures are manifest, for example, in the texture of some membranes, tissues, tubes, hulls, and supporting substances. The fact that even members which appear to be liquid may have their own invisible structures as living members of an organism has recently gained importance for the emergence of a new dynamic morphology because of this newly developing theory of structure. As important as the direction taken by this new morphology may be for human technology, however, it is just as important to the researcher seeking *new and fruitful concepts relating to the structure of living substances*. Such concepts must fulfill the difficult requirement of being valid beyond the limits of what can be seen under the light microscope, and they must not fail us where the microscope image familiar to us becomes an optical void. We must learn, for example, to perceive blood plasma not only as a liquid in which blood cells swim, but also to see blood as a kind of tissue of quite extraordinary stamp, a singular plasmatic complex.

Since modern structure research has become more intensively involved in gaining insight into the hidden structure of blood and nucleus, a new concept of the organism and its cell structure has developed. Until recently, it was commonly said that the more developed organism consisted of cells -- meaning that these building blocks had pieced it together. Today, however, we believe that a more developed organism, whether of the cellular or non-cellular kind, constructs its own structures. These are all, insofar as it possesses cells, of its own creation; it has, on its own, separated into such cells during its early construction period.

Anyone who wishes to understand even a part of today's research into life must take this new formulation very seriously; it should not be considered a mere artifice of speech which could just as easily be put into different words. When biology speaks of the organism separating and constructing itself, it is not striving towards some kind of mystical darkness to take the place of a clear and sober presentation; rather, this emphatic reference to the self-centered activity of living structures is precisely the most factual and sober statement. This statement makes clear to us where the real issue of all research into life lies. It rejects delusive, apparent solutions. Genuine research into life knows something of the grandeur and strangeness of living beings.

CONTEMPORARY BIOLOGICAL RESEARCH

Part II[3]

The Behavior of Animals as the Object of Natural Science

There was a time when animal behavior could be characterized as being a study whose only contribution could be nothing more than a minor addition to various analyses of form and vital functions; anecdotal bits about it were often regarded as mere leaven to a scientific presentation. Some scientists stressed various modes of behavior because they felt that these showed particularly simple reactions to light or darkness, to warmth or cold, and thus that they gave some foundation to the hope that one day this

behavior could be related to physical and chemical laws. For many people, indeed, this had been long the great, if far distant, goal of biological work.

The transformation of this view that has taken place in our own time is perhaps most remarkable precisely as it concerns that distant goal of a physical-chemical explanation of evolutionary processes. Biologists use the methods of physical and chemical research, and they will continue to do so in the future; indeed, it is likely that the scope of the application of these methods will grow rather than decrease. But these methods are used today with the full realization that their results always represent and explain what is only a very narrow part of the evolutionary process, while the whole structure of evolution has its own laws within which the physical-chemical aspect plays a very well-defined and limited role.

The recognition of the relative autonomy of developmental processes in living things is one of the most important findings of modern natural science. This recognition provided the absolutely necessary precondition for the blossoming of the new way of looking at things given us by behavioral science. But, what, exactly, is new? And what is this special way of looking at things?

The decisive transformation is that there is no attempt to understand the construction and activity of an organism through the properties of its molecules; rather, according to this new view, the living thing, right here in front of us, can, for the first time, be viewed as the intrinsically worthwhile object of scientific research -- *even if we consider the entirety of its behavior*! The analysis of this behavior should be just as painstakingly implemented using all the tools of biological research as, for instance, the studies of the construction and performance of a muscle, a glandular cell, or the evolutionary process of an animal nucleus have been previously studied.

The great change, therefore, lies in the recognition accorded animal behavior as an object of natural science. This is indeed an incredible change. It is now being said that the realm of qualities, the sensed singularity of earthly objects, is to be recognized in all its fullness as a scientific object in the whole fullness of its sensed presence, and not merely as something to be translated into size and number.

Let us take an example. When a physicist analyzes a red, he will characterize it as an oscillation of lightwaves, while a chemist will try to determine its elements. The task of both kinds of scientists will have been

completed when the physical relationships have been found and the formula of the element has been stated.

For the behavioral researcher, on the other hand, who, for example, might be examining a butterfly's visit to blossoms or the reproductive behavior of a stickleback, something very different becomes important. What is essential to him is that here is an organism which is capable of distinguishing a color, e.g., a red, as separate from let us say, blue or yellow. The important thing is that an insect can be just as excited by some kind of painter's red as by a red liquid in a laboratory flask or by the red of blossoms, and that the origin of the red color can, in such a case, be totally unimportant.

An important *new* fact is thereby placed before natural science to take into account. Until now, its most important task was considered to be that of analyzing *how* the appearances present themselves to our senses -- all the time keeping in mind questions concerning their hidden components. Then, armed with these analyses, the scientist expected that he would sooner or later arrive at an explanation of both the essence of the thing and of what we sense about it. Today, the riddle of the qualities accessible to sense, merely as sense impressions, are, while still unsolved, become important in the study of life. The fact of sense alone -- and not its molecular basis -- is the decisive factor whose role in the animal world we are trying to discover. Behavioral science studies the roles in the play which life presents to us.

This science sets special goals for itself, goals whose definition and peculiarity might well be obscured for us by the fact that it makes full use of all the methods of physical-chemical analysis used by researchers for the sake of exactness, and that it employs the tools of the mathematician and statistician. Its research tools are instruments of exactness, but the biologists' present goal does not lie in reducing the processes of life to physical or mathematical terms. Rather, its goal is to gain insight into behavior and to learn the importance of objects in our environment which include *both* members of the same species *and* members which represent enemies in the life of the animal!

Another example may clarify the confusion. A biologist determines the entire population of robins within a large observational area. He marks

the birds with rings and spends years following this small group. The goal is not only to determine the number of robins in the area, but also to gain a deeper knowledge of their form of life. The discovery, for example, that single males demand a certain area for themselves, and that, during the breeding period they chase out other males is more important to the biologist than the number of males in an area. Or, using the terms of modern biologists, the robins are marking out their "territory." Another important observation is that the female which has been chosen as a mate, even though it has the same appearance as the male, ignites very different reactions; the female, therefore, has been recognized as something very special. We could spend a long time continuing to list the singularities which transform the territory of the robin into a small, *special*, living space within which many things have meaning and a special purpose in the life of the little bird. The image of its life which has been drawn on the basis of these observations and statistics is not a romantic attempt to weave a kind of small human society around the robin; rather, this new picture of its existence is the result of countless observations made with great care, observations which lead the sober observer who follows the scientific guidelines for his analysis to new insights into a small, purpose-filled robin world -- insights whose contents throw some unexpected light upon our own human existence.

Let me here briefly appeal to the memories of my old readers who are the only ones who will be able to gage completely the extent of the change behavioral science has brought about. They will easily recall a time in which a language borrowed from mechanics and technology was meant to represent animal behavior, a time when science thought that it was sufficient to relate a few extremely basic biological reactions to light, sound, and chemical reactions or to the earth's gravitational field.

If, during that earlier period, someone used the strutting, threatening, intimidating, aggression, staged scenes, emotions, and the like, that person would have been accused of an impermissible humanization of animal life, if not of pure fantasizing. Although there were even then a few criers in the wilderness, even such an important fact as the territorial property of animals, the demand for one's own territory, was scientifically stated only thirty years ago, and it is only within the last two decades that this notion has penetrated

into wider circles of biological research where it is still contributing to the insensible transformation of our concept of animal life.

Indeed, something very significant is taking place. It is a completely new awareness of *the* outstanding fact in the realm of living things, and for many of us it has been an outstanding discovery: the rediscovery of the animal as a *center of experiences*, as a being which constructs within itself its own special world through its experience, and which, by means of this construct, can make a selection which determines which parts of its surroundings will contribute to its *inner property* and what it is which will relate to these things. This, the relation of the living being to the realities of its environment, which is mediated by the inner experience of the living being.

The extent to which a new behavioral science is possible is precisely that to which it is possible to gain knowledge of the inner life of animals. If there are some biologists who avoid the term,"animal psychology", their hesitation is born of their desire to avoid a too narrowly circumscribed and isolated definition of the soul, and, if possible, to make statements exclusively in matters which we can observe externally as facts.

It is for this reason that the behavioral scientist does not say, for instance, that the robin has possessive experiences in his territory; instead, he says that, as seen from the outside, the robin is manifesting possessive behavior or defense of his territory. Armed with such conclusions, the experimental biologist turns to the study of this puzzling reality with a fully and genuinely scientific mode of address -- but only after much tossing to and fro, after many retreats and advances -- and claims that animals are active centers whose "experiencing" involves a more or less extensive *area*, within a period of *time* which may also be longer or shorter in extent. We would like to be able to say that the animal *furnishes* itself with an environment and that it *produces* the flow of its life according to the rhythm of its experiences. In this manner, space and time become richly articulated limbs for the individual. The meadow lark, for instance, leaves its nest to soar into the air; the cylinder of airspace into which she soars belongs to her and she ardently defends it and remains strictly within it in her flights upward. This upward flight, seeming so free, is a severely restricted piece of behavior; it indicates to us, in its fulfillment of space, a fact of the lark's life which must now be studied intensively -- along with the muscle play during the lark's flight, the design of the feathers, its digestion, and its breathing.

But this individual sphere, where space is fulfilled and filled with song, hints of something else as well. The robins of which we spoke earlier, who, we said, protect their territories, are also in contact with the fellow members of their species which surround them. The upwards-soaring, jubilant larks remain in touch with one another by eye and voice. The individual sphere, with its finely fulfilled space which endows the individual with its ownership, only becomes real, after all, when it is one of a number of individual spheres belonging to members of the same species. *It is only within a total space filled with social interaction* that the individual sphere actually develops. The way birds form their flocks strikingly shows us how this characteristic of the individual sphere may change. The same birds which for months eagerly defended a territory as a large individual space suddenly lose this urge and remain together in close flocks during the migration season. And, just as this change occurs, so also the opposite change takes place and the flocks separate in the spring when the individuals pair up. The flock then dissolves. *The behavior in relation to space* occupies the same degree of value as, say, the yearly growth and shedding of a buck's antlers. Strengthening of the body and the soul can, both, be expressions of the changing mood of the animal as it moves through the seasons of the year.

Anyone who wishes to see just how wide and rich our concept of animals is becoming through the impulses of biological work would do well to consider one more example. We have the recent thorough study of a young German behavioral researcher, Dr. G. Sauer, and I quote it rather freely:

> "The richest song of the hedge-sparrow is to be found in its functionless immature song which reaches its highest degree of perfection as early as in its fourth week of life. All its subsequent songs, which will be influenced by instinctive pressures, are simplifications of this first song. Lacking any purpose, this adolescent song is *expressed for its own sake* because of stimuli which it produces from within itself...almost incessantly, rapidly in numerous similar-sounding variations brought forth without a moment's pause. Within the limits of its domain of inherited modification, the bird's song can easily span the entire spectrum of possibilities of its pre-determined musical form-motifs. Whereas, the variation in the functional song of the mature bird is limited and its motifs are stylized.
>
> Undisturbed, just as its song emerges, the singer sits in full view, unexcited, in a relaxed, loose position, seldom changing its place....The bird is *free to devote all its efforts towards its music*."

When we listen to this report, which is the factual presentation of the results of research, we can, perhaps, sense a new mode of speech and, if I can speak in this way, we can sense a basically new mode of thought which such research gives rise to when we reflect on the organism.

It cannot escape us that things are being expressed here which directly affect us as human beings and which clearly testify to the large number of basic experiences which are so widely common in the higher animal world. These basic experiences are also the foundation of the social life of human beings. No responsible person will be able to ignore the many facts which have been discovered already by behavioral research nor those which have not yet been uncovered by it.

The primary help which the new behavioral research can offer us comes out of its more encompassing view of the organism. This is in contrast to the ground covered by other research methods where we are sometimes given the feeling that organisms only served the purpose of producing digestive enzymes and reproducing certain hormones, or that all the organs of the senses and of movement were only meant to provide the inner organs with materials *they* needed in order to do *their* work.

But, it is true that in today's science even behavioral research is exposed to that danger of examining all animal behavior in the context of its survival values, and of denying any other view. Our next contribution to *Recent Biological Research* will therefore present the other side of this question.

CHAPTER IV
Endnotes

1 "*Lebensforschung unserer Tage*," *Universitas*, Heft 3, Februar, 1955.

2 [See: Beklemishev, W. N., *Principles of the Comparative Anatomy of Invertebrates*, (trans. of 3rd Russian edition of 1964 by L. M. MacLennan, 1969; Chicago, Un. of Chicago Press) 2 Vol. Vol. I, pp. 18-23 presents us with a clearly Marxist "scientific" defense of the cell state theory.] (F. N. by trans.)

3 "*Lebensforschung unserer Tage*," *Universitas*, Heft 3, März 1955.

PART III

PECULIARITIES OF HUMAN EVOLUTION

Introduction

In his essay, "Man in the Perspective of the Theory of Evolution," Portmann tell us, concerning the mammal's "compulsion" to drink, a compulsion which is hereditary, that:

> "This drink compulsion of the newborn has become a consideration which has been active in associating the late period of time at which the region of our mouth, nose and throat complex is perfected with the vocal space required for human speech after birth. One of the most striking peculiarities of our higher life form, i.e., the acquisition of speech by means of social contact, stands in an intimate relation to one of the most primitive characteristics arising out of the evolution of mammals: namely, our acquisition of speech is related to an arrangement which both fixes the placement and function of the larynx in the new-born and forces the final perfection of those speech organs to that later, post-embryonic path in which the acquisition of speech in society is also an essential factor."

In this Part III, concerning the peculiarities of human evolution, Portmann's essays discuss one of his most striking contributions to biology--the fact that the human newborn is, biologically and developmentally, still a fetus until it has been "in the bosom" of its family for some 7-9 months. Furthermore, we shall see Portmann's arguments for saying that this peculiarity of human birth and early development is developmentally geared and harmonized to the acquisition of human traditions and human speech.

In short, in this Part III, we shall see Portmann's arguments in support of his thesis that human biology *must* take into account human culture, and that, without such a consideration which includes *both* biology *and* culture, the human individual's biological development makes little or no sense in a large number of cases which include just those features which make us distinctively human.

CHAPTER V

THE PATH LEADING TO WORDS:[1]

LEVELS OF LIVING COMMUNICATION

The evolution of men and the building of a peculiar world of culture in the midst of the wilds of nature is a good part of the product of a particular kind of inheritance which works much faster than other evolutionary processes which we know of -- all of which rest on the change in natural hereditary factors found in the cell nucleus. For quite a while, however, anthropological investigators have known how to explain our properly human path: that is, they oppose the extrinsic, exogenous, or social kind of inheritance to the endogenous or intrinsic mode which employs novel combinations in the hereditary material of the cell -- that is, to somatic developments. Those investigators simultaneously stress the powerful enhancement of reality brought about by this, our peculiar solution.

Tradition: this is the path which our accelerated evolution has followed. This is not, however, solely the prerogative of our species. We know of many groups of animals in which changes of behavior do not rest on processes originating within the hereditary material, e.g., formation of new habits through imitation; acquisition of new living spaces through "acculturisation" -- an especially drastic process in birds and mammals. These same changes in the conduct of life are, however, very different if we compare them with the unfolding of human culture. Decisive for this contrast -- and therefore, comprising the peculiar tool of our evolution -- is the powerful instrument of our spoken word.

Languages are systems of psychical communication between experiencing subjects, and they are characteristics of higher levels of organization. The signs which are communicated can belong to different spheres of sense, for instance, they can involve a combination of motions, together with sensitivity to odors -- the case with bees. However, although

gestures used as means to communicate are widely distributed, the speaking outloud of humans -- their *speech*, as we shall hereafter refer to it -- is to be at the center of our presentation.

This human speech rests on the availability of signs which are independent of any special situation and whose meaning, therefore, must be learned. Even the so-called "onomatopoeic" signs are not immediately understandable; for, words such as "clink" or "splash" must be understood as deriving their meaning from the tradition of the group. Only if we have this knowledge do they make sense.

The function of speech in the human conduct of life involves communication both with himself and with his environment. Revesz (1946) has distinguished three functional areas:

Demanding: The imperative

Signifying: The indicative

Questioning: The interrogative

He collects these three functions under the name, "I-functions"; to these we must add a fourth, the operation of our power to construct representations, that is, the imagination. The three I-functions which Revesz distinguishes all serve to preserve life;[1] however, as is the case with all living productions, speech also extends beyond simple preservation and, in many of its expressions, it is associated with a number of "functionless" manifestations. As we know from many examples taken from the singing of birds, this sort of manifestation is not immediately coordinated with preservation. That is why I attribute special meaning to the fourth I-function, imagination. We sometimes find that behavioral investigation applies this concept of "functionless expressions" of living things to all cases for which no immediate selective value -- and therefore no clear species behavioral meaning -- has been proven. Today, however, complicated social structures are being discovered within which one finds direct or indirect survival values for many such "functionless" activities which enhance the life of individuals and which, to that extent at least, aid the development of the species as well.

Considered as a link in our relation to the world, speech can also be viewed within the polar division into the "ästhetic" and "theoretical" in their widest sense, (as F.S.C. Northrop also uses these terms), in order to include

the polarity of understanding and emotion -- i.e., the "order of the heart" and the "order of reason". In this way, we will include the entire spectrum of speech-functions.[2]

The uniqueness of human speech becomes clear at once if we will only take into consideration the completed formation of the speech organ. To do this, we are forced into making comparisons with the higher primates. And finally, we will come to the old question as to why apes do *not* speak! The most extensive attempts either to discover an ape language in the wilderness or to produce speech in the ape young who have been reared in the human world have always remained stuck at the most simple rudiments.

The first investigations of the vocal organs of anthropoid apes, for which we are indebted to Perrault (1676) and Tyson (1669), stressed, above all else, the general agreement of the organization of the larynx in anthropoid apes and men.[3] They based on this their further conviction that the difference which distinguished men from his nearest form-related animal, i.e., the lack of speech in apes, almost surely rests on the different organization of a central organ, the brain. In this view, the anthropoid apes are not able to speak because their brain lacks the structures on which our thinking depends. This idea, which was also put forth by René Descartes (1596-1650), must lend support to a view in which men and animals were seen as sharply divided from one another. It also implied that there was no need to prove the agreement or disagreement between the vocal organs of anthropoid apes and men. Rather than pursue such an investigation, researchers holding this view stressed the difference of the highest organ concerned with the individual's relation to the world -- the brain. In a letter to the Royal Society concerning the orangutan, Camper (1779) contradicted that view which was then in vogue, but he succeeded just as little as did later individual expressions of this sort. The conviction that the anthropoid apes have at their disposal "our" organs of speech has persisted until today.[4] The conviction will, however, be refuted by a more careful examination of the facts.

It is not enough to find the structure of the larynx in general agreement in men and anthropoids and to identify the same organs in the mouth cavity and the throat. What is decisive is the mutual placement of these structures, together with the differing relationships of spaces which are thereby created and which cooperate in the formation of speech.

In the young of all the higher primates--including the three kinds of anthropoids -- the roof of the gullet, the epiglottis, extends to the back edge of the palate, indeed up above it, both in adults as well as in children, (*Appendix* II). In this way, it permits a path for breathed air which is separate from that of food. Liquid nourishment gets to this post which is near the epiglottis and so into the food-pipe, the esophagus. The elevated placement of the larynx, which permits simultaneous breathing and drinking, is a very ancient characteristic of the mammals. It answers to the demands of nursing, the first phase of feeding in mammals. Even as early as 1889, we find Howes hinting at this interdependency.[5] What is more, it is implemented in newborn humans in all the particulars belonging to the mammalian type; but in apes it persists, remaining as the permanent condition.

In humans, however, a very decisive transformation takes place toward the end of the first year after birth. For, in the middle of the second month after birth, the larynx very gradually moves back a little down the throat. Indeed, it is in the second year after birth that an approximation to the conditions found in adult humans is first reached, and it still requires four or five years more, until the beginning of puberty, for the larynx to reach its final position. Then the epiglottis shows an extensive interval between itself and the back edge of the soft palate. Indeed, this descent has been known of since 1905; but its displacement in position was described quite exactly first in 1939 and 1942.[6]

It is this descent of our larynx after birth which first creates a definite vocalization area for our voice formation. At this point it is not only the nasal cavity which belongs to the area above the entrance into the larynx located between the true vocal chords -- the condition at birth; the throat and mouth cavities, an area in which the movement of our tongue brings to fruition the great potential for the alteration in formation and volume of the hollow space is now also included in this area -- and thereby provides a breadth of variation which is especially favorable for our speech formation. The mobility of the rear margin of the tongue is thereby essentially located within the throat area. The investigations of Lieberman and his coworkers

establish that this pharyngeal region is lacking in the non-human primates, and that its medial section is always changing because of the motion of the tongue during speaking.[7] The results of these investigations permit us to assume that speech is not an additional function which uses what is essentially a breathing or swallowing passage as a developing vocal tract. Rather, the skeleton reveals a series of deviations from the vocal tracts of primates which could, in part, be produced in connection with the production of speech. Studies of Rhesus monkeys, made with the help of computer-models, show that the Macaques have a very limited focal range in comparison to humans, and that this limitation is conditioned precisely by the lack of an area which changes along its medial axis at the back of the pharynx. Observations on anthropoid apes show a corresponding restriction. The human sound-producing apparatus appears to be the specific organ of our species. These results of the most recent American investigations must thus be combined with old insights whose extent has not been valued sufficiently, but which today broaden the picture we have of the specifically human kind. As early as in 1677, John Hunter pointed out that the human dental arch in the region of the milk-teeth changed neither its outside dimensions nor the mass of its tendons, (the "post-lacteal mass" of Louis Bolk), in later maturity, while the corresponding region in anthropoid apes is positioned inside the mature dental arch. The post-lacteal mass of anthropoid apes increases considerably. Interrelated to this is the fact that with the equivalence of the number of teeth in the human rows of teeth, a relatively tight closure of the mouth cavity is made possible. Whereas, the gaps and difference in the sizes in the region of the eye-teeth which is typical for apes abolishes this tight closure in their case. Both innovations cooperated in the formation of our vocal area. Up to now, these phenomena were used almost conclusively in the discussion of Bolk's hypothesis concerning the fetalization of the human form;[8] it was in 1955 that Kipps first located their importance in this evolution of voice formation in man and the origin of speech.[9] Kipps also evaluated the degree of arching of our palates

with an eye to this question (1966) and, like Lieberman (1968), his work shed light on the problem of the evolution of speech in the context of humanization.

I am here going to mention only two conjectures -- both of which are still very much hypothetical which have been derived from these hints. First of all, it is seen as possible that the Australopithecenes lacked a rich capability for speech (Lieberman); furthermore, we have the hypothesis that the Neanderthal man, in spite of a capacity to speak, was perhaps not capable of a complex formation of sounds (Kipp). These hints are only meant to indicate how far afield these new conclusions concerning the evolution of speech are found to range. Laryngeal descent; special ontogenesis of the dental arches; the building up of tooth-formation and its subsequent correlations; the perfection of the palatal arch; the transformation of the tongue: all these processes are at work in the forever hidden formation of speaking during the course of human racial history.

This survey of the particular characteristics of our organs of sound formation would be incomplete, however, without a glance at those new investigations which concern the origin of the vocal chords and their musculature, and which stress the contrast of the human situation with that of the anthropoid apes. It has been proven by K. Goerttler (1964) that there exist special systems of muscle fibers in the vocal chords which, as distinct from the relationships in the anthropoid apes, are attached to the edge of the vocal chord -- muscle fibers whose structure closely connects them to heart muscle (we are amazed by the variety of the sarcoplasma!), just as they also occur in other organs in the upper abdominal region.[10] Furthermore, innervations through the Nervus accessorius of the Vagus hints at this relationship. Investigations of R. Husson (since 1949) concerning the activity of the vocal chords agree with the sense of Goettler's conclusion. In spite of critical objections to Goettler and Husson (*vid.* D. Starck and R. Schneider, 1960), most recently those just-mentioned investigations began to be judged positively through the work of Clauser (1974) insofar as it bears, in many ways, on the peculiarity of the origin of our speech.[11]

The many and great differences found within the group of organs which share in the production of sound can, I presume, be viewed as evidence that man, even in his instrumental equipment, is directed towards another kind of vocal communication than are the other primates. Furthermore, I presume that this organization must be the result of a long, special development. However, this ought not to mislead us now into simply turning around and accepting the old insight of the 17th and 18th centuries in the contrary direction -- that only the instrumental equipment of the voice-forming region hinders the apes from speaking. We must reflect that, even laryngeal surgery or deformities of this zone do not necessarily altogether hinder articulate speaking. We must reflect that the spectrum of behavior possibilities permitted by the central organ of an animal can also be quite strongly restricted. Everything testifies to this as, for example, with chimpanzees, in whom voice formation is resistant to every modification of learning processes -- and this is truly astonishing in this species of primate which is otherwise so well educatable. (We will be obliged to return to this point once again.)

The biological attempt to represent the genesis of our articulated speech proceeds from the working hypothesis that this means of communication must proceed out of preliminary stages consisting of social relationships between primates -- as always, we like to imagine ourselves as being the particular point of this whole evolution.

This particular way of imagining our evolutionary route represents us with the task of investigating our single living relatives in order to try to find what hint can be gleaned from their capacities for communications.

Before proceeding further, we must state that, without exception, we have failed in all our attempts to bring young anthropoid apes (chimpanzees) who have been raised with human children to speak. Indeed, they have doubtlessly provided us with repertoires of different sound formations; but these are not preliminary stages of a word speech. Observations out of captivity also show no sound formation which can be counted as preliminary stages of communication through an articulate vocal expression of a kind which uses words.

G. Schaller stresses how inexact the older observations concerning sound expressions in gorillas really are -- so inexact, indeed, that he was unable to reach any agreement with them in his own experiences concerning this behavior.[12]

In their untroubled daily life, gorillas are mostly quiet. Out of 22 firmly established sounds, he only heard 8 regularly. Of course, the variations in pitch, intensity and form are fairly great and are answered selectively, albeit the place and rank of the member of the group making the sound are important for the answer. The young are usually silent. No one related the most striking sound expressions, namely, those which are associated with the breast-thumping of the gorilla males, to the genesis of speech. They belong to the many-sided expressions of communication of the group -- a characteristic of higher animals.

What meaning these positive gestures can have in gorillas is testified to by the observations of Diane Fossey (1967). In the third year of her contact with the mountain gorillas, she experienced a friendly welcome from a male gorilla. Stretched out on the grass, she scratched her hair after the manner of gorillas. The gorilla, "Peanuts", who was familiar with her and who trusted her, began to do the same. Still lying down, she gently stretched out her hand so that the palm was towards the gorilla, and then she laid her open hand on the tangle of grass and leaves. After a cry, Peanuts came hesitantly closer, stretched out his hand and, just using his finger, touched the observer. He sat down. A moment later, he looked at the hand of the young woman, sprang up, and gave vent to his excitement by drumming a tattoo on his chest. "It was the most wonderful parting gift that I could ever have received."[13]

The observations of chimpanzees living free provide us with a few insights which are significant for our problem. Kortlandt (as early as 1959), but most of all, Jane van Lawick-Goodall, stresses the important role of mimetic communication and the role of gesture. However noisily the male groups of wild chimpanzees gesture, the mothers and their children, to the contrary, behave themselves very quietly. Poverty of sound; quietness in their association with their children: these are the outstanding characteristics of this special relation.

In the wild, chimpanzee children beg food with outstretched arm and with upright palm. Kortlandt stresses how subtly mimicry works: the way the child looks at its mother decides between the young one's climbing on the mother's back or its being clasped to her belly.

Of all the anthropoid apes, the orangutan is least well known in the wild. We received our first detailed reports from MacKinnon whose intensive observations were made in the virgin forests of Borneo in 1968-1970. He distinguished 15 sounds which can be associated with sipping, lip-smacking, grunting, gurgling, and belching or gargling. The sounds are difficult to distinguish and most can be heard only close-by. One far-carrying sound, the "long call" uttered by mature males, seems to serve primarily for the sake of demarcation of the distances between these solitary males who always live separated from one another. This sound is strengthened by the resonance of large throat sacs. But, concerning a complex speech in orangutans, nothing at all is mentioned.[14]

These facts, as well as the newer experimental proof of the incapacity of the anthropoids for a particularly rich variety of sound productions, have thus led us to new ways we must follow in our quest for communication between men and anthropoids. These ways have led to especially rich results.

Now, even as early as in 1925, Yerks had hinted that the desire of anthropoid apes for imitating what they saw and what was striking to the eye is much greater than for what they hear. Consequently, many observations lead us to choose a system of gestures as the means to a deepened communication with the chimpanzees.

Beatrice T. Gardner and R. Allen Gardner at the University of Reno, Nevada, have followed this path in a large-scale investigation.[15] As their means of gesturing, they chose the American deaf and dumb language in order to associate with a chimpanzee child which had been brought out of the wilds. Their attempt was successful. The chimpanzee, little Washoe -- then somewhere around 8-14 months old -- matured within a group of humans who only communicated with one another with this sign language and who carefully avoided the use of verbal speech in the presence of the ape child. After 7 months, Washoe understood and used 5 signs and after 7 more

months, there were as many as 25 signs. After a total of 22 months of training, there were 30 signs at Washoe's command and, after a total of 36 months, there were 85 signs! Washoe was at this time somewhat less than 4 years old -- the time of life in which the wild chimpanzee child is separated from his mother. (Sexual maturity sets in with the 7th year.) There is no reason to suppose that Washoe could not have been trained further in the use of sign language after this first period of childhood. Her body development was stronger at the end of this experiment than the norm for chimpanzee females. By 1970, the 80-pound child presented quite a few problems in living at home.

At the time of this present report, (1972), Washoe is incorporated into a small chimpanzee group, where, at the University of Oklahoma at Norman, the investigations of chimpanzee communication is being pursued further.

During the time in which the investigations with Washoe were being carried on, David Premack at the University of California, Santa Barbara, was pursuing goals similar to those of the Gardners in Reno. Premack used the female chimpanzee, "Sarah", who was about 6 years old at the beginning of the experiments.[16] Premack chose as means of communication a system of plastic signs of different shapes and colors, signs to which we gave word meanings during the experiment but which could not suggest, either in their shapes or colors, the content of the word.

The signs used could be compared to an ideographic writing which is not so far removed from the signs of Chinese writing. Whether by chance or not, Sarah read these signs in vertical sequence from bottom to top! The "play" with the plastic signs immediately lost meaning if the human trainer was not present. The primary motive for work was social contact.

These two experiments with Washoe and Sarah yield an astonishingly similar number of communication signs and similar syntactical structures of communication, although the old Sarah was a match for more complex situations than Washoe was -- which perhaps may be a question of age.

Our survey cannot further pursue those more advanced experiments which go beyond merely the first beginnings of speech-like communication between apes and men. One of the distant goals of this work is to influence a small group of anthropoid apes using members of its own kind who have

learned a simple means of human communication which uses signs. We have proceeded from the demonstration of the distinction between form and function which divides the human organs of sound formation from those of the anthropoids and the other apes. The new ways of communication reveal that along with the detour around verbal speech, hidden capacities for the social relationship become active -- a fact which will become important for future judgments concerning the genealogy of our speech. At any rate, all the most recent researches which are devoted to this question lead us to the conclusion that the anthropoids, (with the vocal organs we find in them at present), would not be capable of articulated, vocal, speech, but that their brain can perform more than many biologists and philosophers had at one time believed they could. (*Vid.* below, for the problem of brain sizes.)[17]

The final perfecting of our most important, unique, mode of communication is a *post*-embryonic event which presupposes intimate involvement in a way of life involving an historically determinate speech group. The proper organs of word formation reach their functional maturity in temporal correlation with the acceptance of the traditional values of the group. This relation between organ formation and behavior, however, is the continuation of the developmental process begun long before birth, a process which makes possible the advances of the first year after birth. It is in this phase of life within the body of the mother that we must seek the earliest preparations for the speech of the future.

It has already been a long time since I, myself, assembled proofs that the ontogenesis of the human brain which is typical of the mammalian group requires that the fetal period last until the end of our first year after birth.[18] Fetal characteristics of this first year are known: need of care; the answering care of the mother and the group; but, also, a fetal rate of growth which, in the same period of time, achieves about double the result of the development of anthropoid apes. Thus, indeed, among humans a birth weight of about 3200 grams on the average is reached, while newborn anthropoid apes realize about 1500-1800 grams as their average birth weight. The ontogenesis of the speech organs in their form and function occurs in a fleeting transition of the uterine period into the post-parturative period, and we can perhaps signify this latter as the "social womb". What do we know of the pre-parturative

period when we ask questions concerning the ontogenetic beginning of speech?

The birth phase of breast-feeders, (mammals), is characterized by the separation of the food passage from the air passage of the youngsters. The delayed descent of the larynx is related to this necessity. On the other hand, the birth cry of the newborn testifies that the structures of the sounding organs already function during that phase of life. We must take these interrelations as our starting point.

The organs which are in the service of hearing are completely formed quite early in the uterine period of life. The nerve associated with the sense of position -- the vestibular nerve -- gets its myelin sheath in the 24th week, the auditory nerve proper, somewhat later. By the 27th to 28th week, this organ is fully functional. There is evidence that sensitivity to external sound is operational at about this time -- in the 7th month. The structures necessary for sound formation are likewise already prepared to function around the 8th month. Conditions found in the development of fetuses which had to be removed from the body of the mother when they were 28-33 cm. in body length permitted soft sounds to be heard when they were in the open air: the birth cry is prepared even at that time.

In the last months of pregnancy, the organs required for our later acoustical relation to the world are therefore already active. They are prepared for the reception of stimuli. During this time these stimuli are principally those originating in the mother's body, among which her heartbeat is surely the most important and, because of its regularity, the most potent. Even in the investigation of the early period of development, the sound of the mother's heartbeat is nowadays given special attention -- as opposed to the earlier view which was convinced of the relative deafness of human children prior to birth.

Investigations concerning the effect of the mother's heartbeat on their newborn children in the first four days of life are informative. (Experiments in the City Hospital of Elmhurst, New York, have been reported over a period covering 1961-1963.) First of all, preliminary experiments established the quieting effect of the sound of the mother's heartbeat which was sent out over a tape recorder. The effect also confirmed the principal experiment in

which 102 children were tested in their own rooms with the sound of a heartbeat (72 beats per minute), but then in which 112 newborn were tested in rooms without this environmental stimulus. Every 7.5 minutes the noises were registered in the rooms -- each always containing 9 children. In four days, cries were registered during 38.4% of the total time with the heartbeat playing, but, in the other group, 59.8% of the trial period. It was clear that the absence of the sound of the mother's heartbeat resulted in greater restlessness.[19]

A differential change in the body weights of the two groups was also found. (Here, the initial weight is important.) For, in the series with the heartbeat playing in the room, the average gain in weight was greatest (85 grams) among the smallest initial weight, while those in the control group showed a small weight loss (15 grams). Among the heaviest of the newborn (from 3510 grams on up), the average weight loss for those with the heartbeat playing in the room was about 10 grams, while in the control group there was a loss of about 20 grams. We can perhaps draw the conclusion that the lightest children are generally somewhat retarded in their level of maturity and that the rhythm of the heartbeat in the environment of these children has a positive effect which fades away in the case of the more mature.

We must therefore pay special attention to these investigations because they give us a glimpse into the environment of the unborn during the period of life which is only accessible to us indirectly. Experiments which investigate the influence of different stimuli on going to sleep in children (this time, from 16 to 50 months old), show us an effect produced by the double-rhythm heartbeat which is strikingly quicker than that of the simple beat of a metronome or of a lullaby and other soft noises. It was found that, whereas when a metronome or lullaby was played, an average of about 50 minutes elapsed before the infants went to sleep, that time was reduced by the sound of the heart rhythm to somewhat less than half! This conclusion opens up the possibility to us that the early uterine "experience" of the mother's heart pulse has some very many-layered effects on behavior, and that it can very likely be associated with the genesis of speech.

Certain of those possibilities first realized during the first phase of speech formation after birth are already co-determined through the earliest experiences of life in the body of the mother. Such experiences of "primal sounds" might, in the pre-parturative life period, also play a role in the imitation of sounds belonging to the social environment. The relatively dumb period which, in the third month characterizes the child's transition to word speaking, separates the early period of babbling from the acquisition of group speech so strikingly that this period appears to be especially occupied in paying attention to the peculiarity of the earliest sound formation.

Speech research has stressed the importance of the two syllable form -- the pre-eminence of double sounds such as *ma-ma, pa-pa* -- as the preparatory stage for specialized speech. These quite general and numerous speech precursors suggest that we should relate this striking peculiarity to the early formative experience of the mother's heart rhythm. Access to a sure insight into this first phase of living is difficult, and, indeed, none of the investigated peculiarities may be left out of our accounting if we wish to determine the different springs of experience out of which our ontogenesis in the period before speech arises. "Every child who is learning speech and who is somewhere between the 4th and 11th years is a genius. He thinks more than the average man (who, unfortunately, he will then later become), and, out of this thinking, with the help of speech, he builds for himself the individual world of his experience." So judges the anatomist, Kurt Gorttler. He thereby reminds us of what complex events must exist in advance to make it possible for this "phase of genius" lying within the genesis of our relation to the world to happen.

More exact experiments concerning these inherited processes are only very fragmentary in the case of human life because the possibilities for planning experiments are very restricted in number. The total broad circle of biological insight into infantile life thereby becomes so much the more important, and therefore comparative investigation also provides important results.

The situation which lies at the end of our divergent human laryngeal development is the nourishment provided in the nursing infant. This makes it necessary that there be a separation of the air passage from the milk

passage in order to permit simultaneous breathing and drinking during a number of nursings, each of which takes some time. The late perfecting of our speech organs therefore stands in a complicated relationship to the peculiar early period of mammalian development, and that development in earlier geological times is the great puzzle of developmental research. We must be well acquainted with this problem if we wish to investigate our speech in its many-sided conditionality.[20] We are all well aware of the petrified evidence of mammals. Some of this evidence dates from the early "geological middle ages," out of a time whose beginnings reach back some 220 million years. Such fossil remains foreshadow some six different lines of development in which mammals have arisen out of reptilian forms. This evolution has not only shaped new animal forms, but it has also permitted the peculiar early development of milk drinking forms which feed by nursing when young -- in the oldest groups of these nursers, as completely helpless "nest-huggers" (altricials) such as the new-born rats or the tiny young of the pouched animals. The later evolution of milk drinking nursers then developed the "nest-fleers" (precocials) such as we know them in hoofed animals, whales, and apes. On this advanced level -- advanced because of their increased brain development which is characteristic of the highest primates -- the anthropoid apes and young human animals, both of which will be dependent on their mothers, are pre-eminent. Humans are a late, *second* form of nest-hugger. I have considered this peculiarity of human newborn babies in detail elsewhere.[21] Here, only the peculiar phenomenon of the late descent of the larynx will be considered.

It has already been stressed that the initially elevated position of the larynx, particularly the contact of the epiglottis with the back edge of the palate, is a condition for the undisturbed drinking of milk by the nursing youngster. This provides independent paths for breathing air and the first nourishment, which is liquid. This early separation between the air passage and the food passage is especially remarkable in the young of the pouched animals. In these, the mouth crevice grows together around the mother's nipple into a thick seal so that the young remain, so to speak, grown together with their mother for a long time. In many zoological textbooks, this extreme is held up as an exceptional case, and it is consequently nearly always

overlooked that it is only an extreme case of a formation which is important for life and which applies to *all* newborn nursers.

New and detailed comparisons of the different paths of development of embryos of nursing forms living today encourage the biologist to make inferences concerning the development of archaic nursing forms which have died out. One of the most certain among these inferences appears to be the hunch that milk production by the mother and milk drinking by her offspring belong to the earliest characteristics of mammalian evolution, and we can conclude that this apparatus remained preserved, with important consequences, in the later delineation of characteristics belonging to the mammalian type.

This "drink compulsion" of the newborn has become a consideration which has been active in associating the late period in time at which the region of our mouth, nose, and throat complex is perfected with the vocal space required for human speech after birth. One of the most striking peculiarities of our higher life form, i.e., the acquisition of speech by means of social contact, stands in an intimate relation to one of the most primitive characteristics arising out of the evolution of mammals: namely, our acquisition of speech is related to an arrangement which both fixes the placement and function of the larynx in the newborn and forces the final perfection of those speech organs to that later, post-embryonic path in which the acquisition of speech in society is also an essential factor. It is certain that the prerequisites for later speech are, within our process of development, already present in the young before it is born, and, that a retarded maturity which is very thoroughly ordered by inherited factors effects this. This situation in humans provides us with a hint concerning corresponding developments aimed towards a higher level of relation to the world in groups other than the primates. Daily experience testifies to these higher levels and scientific experimentation has analyzed it yet more concretely.

The capacity which birds and animals have to quite precisely comprehend a seen, (and hence simultaneously presented) or heard, (and hence successively realized), manifold as being a "number" of something shows the complexity of these psychic capabilities. In birds, such

comprehension of a "number" reaches to 5, and possibly to 7, and, in some animals this is accomplished in many cases both simultaneously (optically) as well as successively (acoustically). In a test, a grey parrot changed over from light signals to flute signals. In contrast to this, the simpler psychic level of fishes merely developed a distinction between one and "more". Whether on the basis of these performances just mentioned one ought to speak of "counting" or, more neutrally, of "seeing or hearing of numbers", is a question of definition. There is a very deep level on which we associate speech as co-determining our numbering, and this holds whether we perform the process silently or out loud.

The significance of this pre-verbal recognition and association with things in the environment is underscored by Michael Polanyi, who called it "tacit knowledge".[23] We share this unspoken, articulated, psychic power with the animals; it is at work in children during their period of speech development in a very special degree, and Polanyi recognizes that, when it continues on into our later life, it comprises one of the characteristics which quite specially mark out the man of genius.

Whoever wishes to grasp the meaning of this pre-verbal communication for our human life fully will have to immerse himself in forms of life which are both close to ours as mammals and which, in spite of the lack of a speech in our sense of the word, have realized a very rich social life. I am here reminded of the whale, into whose life we have gained many new insights during the last decade and which has come to be recognized as having one of the highest of relations to the world. They are especially important for our problem because investigators believe that whales have a kind of communication which does not preclude a very intense communication with us humans.

The development of the whale's brain is so high that the mass of this central organ equals that of our own. The dolphin, especially, shows a relative brain weight which can be compared to that of men. To be sure, we are never permitted to forget how difficult it is to compare the body weight of a water mammal to that of one which lives on dry land. Nor it is any the less easy to obtain a firm hold on the Archimedean principle of weight reduction in water than on the role of the streamlined shape in such cases. But, the

complex of behavior, the very ancient relationships between dolphins and the fish of all seas, these demand a scientifically-based comparison. Now, mass development can be so computed that difference of body mass can be adjusted for in the ratio between brain and body mass. In this way, we obtain "indices", (*vid.* the following table), whose method of computation cannot be explained here.[24]

The following table gives indices for the total brain and for that part which is important in regard to the animal's relation to the world. It shows how near the dentate whales (dolphins and sperm whales) stand to the human indices, and how much lower the value is for the man-like primates. The value for the Indian elephant is included by way of comparison for massive land mammals. The huge baleen whales are strikingly different from the dentate whale.

TABLE

Species	Brain Total	Mantle of the forebrain (Neopallium) in % of the total brain wieght
Man	214	79.9
Dolphin	159	80.0
Sperm whale	200	87.2
Baleen whale	46	---
Chimpanzee	62	77.7
Elephant	150	69.3

A balanced judgment however, requires that we take into account the salient characteristics of the primary senses. For, only 1/10th of the nerve paths with which our own eye is supplied lead into the brain of a dolphin from its eye, but the nerves of the region of the ear contain 2-1/2 times as many fibers as that of humans. Our adult hearing threshold lies somewhere between 40 and 22 thousand Hertz -- in nursing infants, it is as high as 23 thousand. The threshold for dolphins lies around 500 and 85,000 Hertz for sounds which are components of their social relations. Particular vibrations

from 15,000 to 150,000 -- and sometimes up to 200,000 -- serve for echo direction-finding in the dentate whales.

The sound-producing apparatus of the dolphins is very different from ours. The whales lack our vocal chords. Sounds are produced in complicated nasal areas, and the role played by the larynx is by no means clear.

Since the middle of our century, there have been increasingly numerous attempts to make use of the relationship based on sound formation for a deeper understanding of the hearing-world of the dentate whales. On the other hand, there are experiments of a military nature in progress whose aim is to make dolphins tools of men. I know too little about these experiments to be able to criticize them. A report of the American undersea laboratories, "Sealab II", testifies to the practical result: Tuffy, a trained dolphin of the group of Sporting Dolphins (Tursiops truncatus), was paid by being fed when he reacted correctly to an electronic stimulus. In an experimental test, he brought a line to a "lost" diver who, with the help of the dolphin, could find his way to an underwater station.[25]

The researches of Dr. John C. Lilly on the tropical island of St. Thomas in the Caribbean Sea serve the more general purpose of establishing a true communication with dolphins, and, since the procedures in the two experiments of the two Gardners or Premack were altogether different, a check on their work was also a consideration in Lilly's work. Beginning in 1957, Lilly sought contact with the great dolphins of the just-mentioned species, Tursiops, whose love of play and sociability has become well known throughout the world by means of the exhibitions put on at the great aquaria.[26] A co-worker, Miss Margaret Howe, lived in close contact with a young female Sporting Dolphin, Pamela, during a 14-day preparatory trial and spent as much time as possible in the water with the animal during training sessions. The main experiment took place from June to September of 1966. Miss Howe likewise lived with the dolphin, Peter, for two months, and during that time she transformed the dolphin from an impetuous partner into a very cooperative one and worked towards an acoustical relation with the greatest patience. Dolphins, during their work with humans, learn to do this by forming sounds above water instead of under it. The dolphin

answered in the 4th week and produced up to 95% of his sounds in a manner which Lilly and his partner, Miss Howe, characterized as "humanoid". Several of these sounds resembled the much used words in the experiment -- e.g., "hello", "boy", "ball". If the results depended on a reward of fish in the beginning of the experiment, later the animal's very enthusiastic answers were rewarded only by praise and blame.

On the one hand, these facts appear disappointing and, on the other, full of promise. In any case, they bear witness to the attentiveness and gift for imitation of the dolphins. It further suggests that there exists, between members of the same species, an expression-rich communication which, for the time being, is still not accessible to us.

Lilly's extensive investigations, what is more, lead to conclusions which are of general significance for the problem of speech using words: the question of the lowest order of magnitude of a brain required for the origin of speech in mammals. It is possible that the complexity of cerebral structure which is required for an articulated word-speech which expresses a poly-potential world relation is first realized by a very considerable mass development of the central organ.

In this respect, three peculiarities fall into place so as to comprise a single whole:

1. The brain size of humans at birth is about 370 grams. In the decisive phase when word-speech is acquired, the weight of the brain amounts to about 900 grams.

2. The Tursiops dolphin reaches this limit at birth or has at birth already passed beyond it. This agrees with the fact -- whose meaning was pointed out by me as early as in 1942 -- that the conditions at birth typical of the mammals are, among humans, completely realized only at the first year after birth.

3. The brain of early men of the type represented by Australopithecus reached a volume of about 750 cm^3; that of the early Homo erectus, (Peking-man, Java man), around 900-1000cm^3. The investigations of the palatal and pharyngeal regions, of which we have already spoken, permit us to entertain the suspicion that a highly developed, proper speech was still denied to the Australopithecenes, while the Homo erectus stage was already capable of speech. The anthropoid apes, with an average brain mass of

around 400-500cm^3, remain far under the brain mass demanded by the hypothesis given above.

Be that as it may, the working hypothesis must be ventured that the brain mass of 900cm^3 is the value which must be reached and passed in order to allow for the origin of our speech or even of a similar, not-yet conceived of, communication along acoustical lines. Many researchers refer to this as being a "Rubicon" of speech possibility.

This hypothesis forces us to consider once again, from a perspective which has been largely ignored, the already mentioned experiments concerning the capacity of anthropoid apes to communicate by means of gestures. At birth, the brain of these anthropoids has reached a weight of between 180 and 200 grams -- according to the few specimens we have had at our disposal -- and by maturity, they weigh 400 grams or even a little more. The learning period of Washoe began towards the end of the first year; meanwhile, the chimpanzee child, Lucy, was trained in Norman, Oklahoma, in the same, albeit further improved, way, and she acquired the same fund of signs of the deaf and dumb language in months. A brain size which lies far beneath that of the mature anthropoid brain is therefore already so organized that it can realize the social relation through a complicated sign-system designed on an optical basis!

Within the water world, the dentate whales have up to now claimed the center stage in the area of research concerning the most advanced performances of mammals. The difference in brain index (as *per* the table above), in which the baleen whale is so much lower than the dolphin or the sperm whale -- no less than the legendary fame of Moby Dick -- promoted this one-sided view. Since 1968, however, the baleen whales, the giants of the seas, have been observed again quite attentively. In that year, the American neurologist, Dr. Robert Paine, registered sound formations of the humpback whale by means of underwater recordings which captured the most fascinating and beautiful songs which he had ever heard in the wild world. The recordings of the songs of these whales, nearly 50 feet long, have inspired the American composer, Alan Hovhaness, to write his work for the

orchestra, "And God created the great whales." It was premiered on the 11th of June, 1970, by the New York Philharmonic.[27]

The peculiarity of the life form of the great water mammals deepens our insight into our own special world. The whale group has arisen out of quasi-predatory mammalian forms, perhaps 100 million years ago; that is the same period as that in which the primates and mankind began to arise out of far distant relatives of our hedgehogs and shrews. The scientific belief that evolution has been explained on the basis of those facts already in our possession today has led many investigators to be convinced that these evolutionary events -- whether they lead to the whales or to mankind -- are essentially known. I do not share this certainty, no matter how much I still value the results of genetics -- because now, as ever, the events raise too many questions for the investigator. If, on the one hand, our keen scrutiny of the traces of life within geological history forces us to accept the above-mentioned events of evolution, so however does that same keen scrutiny also require us, on the other hand, to leave open the unsolved questions about the individual steps in that evolution. This is the case even if we must accept that some 30 million years before, perhaps already earlier, the separation of those paths had taken place which subsequently led from the ape-like forms to their human evolution.

The highest levels of present-day evolution of the nervous system have been reached in both developments: similar brain masses therefore compel comparison. The fact that, in spite of these agreements in the world of the whales, nothing of the humanly comparable, artificial world -- nothing of material culture -- has been constructed which reminds us of important contrasts between the two paths of evolution.

One of these paths leads to the ideal torpedo form, to streamlined bodies which are capable of the highest achievements as swimmers. The hind limbs have been sacrificed in favor of this formation, and the forward limbs have been sacrificed in favor of effective fins.

The other path leads to a completely different transformation -- the paired limbs: to hand and foot. The perfection of the hand accompanies the erecting of the body; that perfection, what is more, was perhaps realized before a truly human speech could develop. It can be taken as certain that

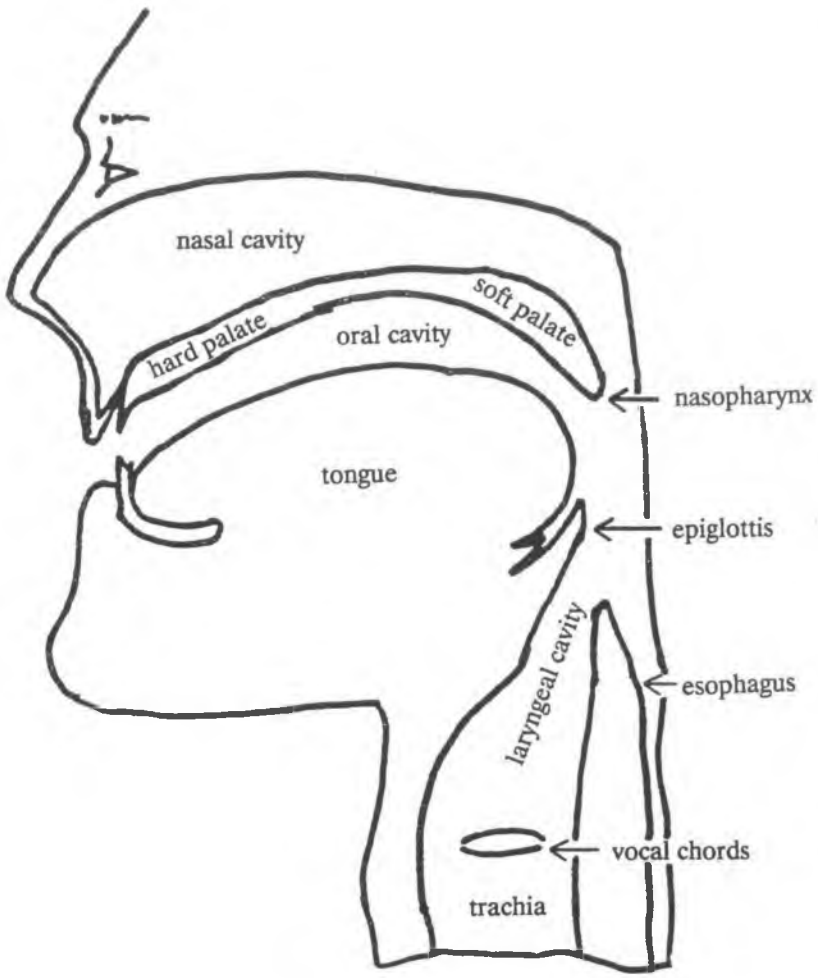
the refinement of the hand proceeded hand-in-hand with a consequently richer binding of that organ of world-relation to the highest nerve organs and the sense-organs. What is more, the construction of a properly human world rests in the polypotent possibilities of "handling", of "manipulation" in the widest and highest sense of this much misused word. Not only spiritual worlds of imagination, but also a material, intermediate world which changes more and more and threatens the original wilderness rests on these possibilities. The many-sided use of the hands and the unfolding of word speech are closely tied together with one another. As Revesz says: "The transmission of concepts, ideas, intentions and volitional impulses comes to influence us largely through sensible contact, namely, through the living word, through the viewing eye, through the hand which touches....In this sense, the hand builds the bridges between the psychic and the somatic spheres and produces the sympathetic bonds which are found between humans."[28]

Observation of the higher forms of water animals, the dolphins and whales, reminds us of what a vast difference in evolutionary paths the transformation of the forward limbs into a one-sided, advanced organ of motion -- the fins -- signifies. The comparison of the two life forms having the highest brain formation places before our eyes what privileges the transformation of the primate hand into the human hand gives to us, but, also, and at the same time, the responsibility which such a favorable advantage entails.

Even if we experience the evolution of humans as a process, one which has been brought to fruition over millions of years, and even if we believe that we know many of the individual steps of this event, the mystery of this hominization is nevertheless still enshrouded in as deep a darkness as ever. Perhaps that mystery will not be unveiled -- at first, just a little, and then, finally, altogether, in the illumination of individual factors and processes; for, the eye of the investigator is struck much too much by a unity in which the uprightness of the body, the evolution of the brain, the descent of the larynx and the genesis of speech accompany the emergence of reason and understanding into the peculiar world relation of the species, man.

If the special development of our larynx, in its correlation to the possibility of speech, stands in the center of our survey, I still hope that the close interconnection of many not yet investigated processes might become clear and point to the realm of the unknown.

APPENDIX II



CHAPTER V
Endnotes

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CHAPTER VI

HUMAN BEINGS

IN THE PERSPECTIVE OF THE THEORY OF EVOLUTION[1]

To the extent that they have touched upon our origins, recent investigations into records manifesting geological history have given us several essential insights. For example, the relatively early separation of the hominid line in the course of the history of the race has been placed far off by the paleontologists; there is real disagreement as to whether that separation of the two great groups, humans and anthropoid apes, must be pushed back 25 or 30 million years, or yet further. We all know that, on their part, the biochemists and geneticists have quite recently proposed a date for the separation of those lines which lies closer to our present; for, on the basis of their computation of mutation rates and the differences in the structure of albumen serum, they have chosen a point 6 million -- or, at most, 10 million -- years ago. The paleontologists are very skeptical about this and the field for investigation is wide open.

The rapid development of behavioral science has given us important results which bear on the problem of human development; within a short span of time, it has illuminated questions which the study of fossil evidence must almost always leave open. What is more, we have quite recently learned how to think about the manifold social formations of our nearest animal relatives, the primates, from a more intimate perspective. But, first and foremost, we have seen light being shed on the life of the great anthropoid apes, studies of chimpanzees and gorillas as well as of the other groups of apes. (This took place during the period extending from 1960 to present.) This made it possible for us to uncover different variations of social structure which imply questions for the pre-human phase. We also know the childhood phase more exactly. For we now understand the strong attachment of the mother as well as the phase, lasting for years, of the

immaturity of the youngsters, and we now grasp the meaning of this long early group period. The formation of habits which are parallel to deeply set instincts is essential; through our observations in zoos, we have established how much social contact teaches the maturing female anthropoid apes concerning mothering behavior. There are many prerequisites which, already present even during the pre-hominid form of life, prepare for the development leading to our form of existence which, at that time, was still very open. These preconditions have recently been taken out of the stage of guesswork and they must now be numbered among relative certainties.

But, whoever pays attention only to these positive details will necessarily misconstrue the unusual character of the evolution leading to man. It is not difficult to understand that with our insight into the facts of evolution of living things, every characteristic which can be conceived of as constituting a step on the way to the human life form has grained special attention and has been valued as contributing to the understanding of our change in form. However, the more clearly the agreements force themselves upon us, the more self-evident do they appear to us and so much the more inessential their demonstration becomes -- but, by the same token, so much the more do their individual differences which are not yet explained by means of the demonstration of the general relationship of forms, come to the fore.

The Problem of Speech

Our speech is, presumably, the mark which most strikingly characterizes the human way of existence as being the expression of a special relationship to the world. No one doubts that we are related to the anthropoid apes. Therefore, the question impresses itself upon us that much the more forcefully as to why these "wild men" -- as they were still called in the 16th to 18th centuries -- do not speak, and why they do not learn to speak even after the closest contact with us.

There has been an answer which put our minds to rest for all too long a time -- indeed, for as long as 300 years! For, early anatomical investigations claimed to have confirmed the hypothesis that, because the organs of speech formation were so similar for apes and men, the anthropoid apes' inability to speak must be based on brain structures! For a long time thereafter, further details were brought to light which should have broken this spell. Especially revealing were the new investigations which dealt with the descent of the larynx, a signal event for man. Although the significance of this event was described in 1899, it was ignored until a few years ago. This event is the same for the young of all mammals: immediately after birth, they must all be able to drink milk and breathe while they are actively nourishing themselves on milk. The epiglottis, a covering placed high up in the throat, rests on the upper soft palate and guarantees a separation of the swallowing passage from that for breathed air. The animals retain this arrangement in their mature state, and this is also the case for all sub-human primates. This division is so drastic in the young of the pouched mammals that it was noticed very early, and the same thing is true of the extreme expression of this condition in the case of the whales. But, the fact that this apparatus is found over a spectrum general enough to embrace both marsupials and whales did not prevent it from being more or less ignored. In the case of humans, however, the larynx shifts after the first months of nursing. Toward the end of the first year after birth and from the second year on at the latest, it recedes a few centimeters during a process which takes years and continues until the final position is reached by the beginning of puberty. As distinct from the other mammals, there gradually arises for us a peculiarly constructed space in the throat which considerably widens the space for vowel-formation over the tracheal orifice between the vocal chords. The mouth cavity, together with the throat and nose area, thus forms a complex system whereby the nimble tongue is enabled to shape the space in the throat in every different ways. These relationships were sufficiently explained in 1968-1969 to establish firmly the incapacity of all apes for clear word formation, (*vid.* Appendix II).

The fact that this developmental step can be first completed after the period of nursing has important consequences for that perfection of our

power of articulation which permits word formation to begin in the second half of the first year of life after birth. Brain development has, of course, its share in these complex events; however, we have learned that we must also reckon with other factors entering into voice formation if we wish to evaluate correctly the degree to which the structures differ in anthropoid apes and men. The primary facts -- namely, that the sucking young nourish themselves on milk, and the uniqueness of our speech development -- stand together in a very complex interdependency which illuminates our first years of life from a new angle. These investigations produced an important new result, namely, they forced researches into anthropoid apes to take into account the meaning of kinds of social relationships other than those which are made possible through sounds. We today understand the failure even of very devoted efforts to create deeper relationships with anthropoid apes by means of our uttered speech. And so, the psychologists finally found the way to a beginning of a more intimate understanding with the anthropoid apes through the development of the gesticulated speeches such as had been created for communication with the deaf mutes, (R. A. and B. T. Gardner; Reno, Nevada, beginning in 1966), or by means of a visual sign speech with the help of the optical formation of signals, (D. Premack; Berkeley, 1970). Both indicate a rich brain capacity in these higher primates. New attempts involving the solution of really quite complicated visual problems in experiments with chimpanzees reveal the same thing.

The separate direction of all those evolutionary lines which we collect together as being "human" leads us to the absolutely clear fact that we, as distinct from the other higher mammals, acquire three important characteristics early in the time of life after birth. These are:

Upright posture;

Speech;

Thought.

All three are acquired in the second half of the first year or, at any rate, toward its end, and all three presuppose intensive cooperation on the part of the social environment, without whose stimulation and help the development into a truly complete man is not achieved. No other higher mammal acquires the posture belonging to its kind in this way, and in others, the processes of

maturing which are pre-supplied by heredity, are always decisive -- even if imitation and tradition have their significance. The harmony between the developmental period and the requisite cooperation of the social group for the training which is concerned with upright posture, speech, and thinking, leads us to look at a central peculiarity of our development.

The Path Characteristic of Hominids

This is a significant, even if little observed fact whose meaning only emerged as it was being considered anew. The pediatrician, E. von Lange, had, as early as in 1903, observed that the mass increase of human children in the first year after birth equals the total mass increase of the fetus from its beginning; whereas starting with the second year, a remarkable slowing-down set in. This persists until puberty and is not changed even throughout that general acceleration characteristic of youth. The temporally equivalent weight curves of the anthropoid apes for these first years proceeds in a strikingly different manner. This fetal growth-rate is very gradually passed beyond in the later phase of childhood. The human curve is steeper during the first year than those of the orangutan, gorilla and chimpanzee; in the second period, however, all the curves of the apes are steeper than ours, and they remain so until puberty. The conclusion of puberty is yet a further typically human developmental characteristic. These facts have remained strangely unnoticed, even though these aspects of fetal growth were pointed out once again by the American anatomist, Richard E. Scammon, in 1922. In order to prepare us to understand these peculiarities of our growth, we must take notice of still other particularities in the conditions both of our birth and of the first developmental phase outside the mother's body.

There is the matter of the development of our brain weight. In comparison to its final weight, the weight of the brains of the anthropoid apes at birth has reached a much higher mass-development than we find in the case of our own central nervous system. After birth, the ape brain grows barely 1-1/2 to 2-1/2 fold, and this exactly equals the growth type of very many higher mammals -- for example, that of the ungulates or hoofed

animals. A macaque of Gibraltar or North Africa, a chimpanzee, a deer or zebra; these all show very nearly the same post-embryonic brain growth. But, the human brain must continue growing by a factor of four in order to reach its final form. If the researcher seeks after that phase of our youth in which our brain weight is equivalent to that of a newborn ape's, he finds this stage at the end of the first year of life -- but this is just where the fetal weight type changes into the period of slow growth.

A thought-experiment will lead us somewhat further. We are looking for the characteristics of these birth conditions which would be attached to men were they to develop in a purely animal-like manner -- say, as do the foals of horses, or the calves of deer, or as the young of the macaques or the anthropoid apes. These newborn "animal men", these "man animals", would, of course, need to have their species' body posture -- and with us, therefore, the upright posture -- and thus the ratio of trunk to limb mass would have to equal that of an adult. They would have to be able to show us a brain, as we just said, which would increase its mass only by a factor of somewhere between 11/2 and 2. These are all characteristics which are realized by us exactly at the end of the second year of life. Our period of pregnancy must be prolonged up to this year -- and therefore, it would amount to about 22 months in all.

Our children come into the world a full year earlier than it would take for an actual animal-like sort of development; they are, at birth, incapable of the upright posture which typifies our kind, and the proportion of their limbs to body weight is far removed from that to be found in the adult.

At birth, the newborn human child is much more helpless than a newborn elephant, whale, or macaque. It is not for nothing that this condition has been compared with the helplessness of young rats, mice, moles or with that of many beasts of prey. We are representative of "nest squatters", (altricials). And yet, our conditions differ strikingly from that of other nest squatters. For, our eyes are open at birth and our auditory organs are likewise entirely developed, whereas the eyes and ears of other nest squatters are closed, and they open first only a considerable time after birth. Yet, we still run through this stage of closed sense-organs within our mother's body where, in an earlier time, the eyes and ears were closed against the outside -- which is entirely unnecessary in the hidden recesses of the mother's body!

All higher mammals run through this stage of the closing of the senses within the body of the mother. The biologists detect in this repetition an event anchored deeply in the inheritance of the higher mammals, an event which actually occurred to them in that far-distant time which entertained the presence of the class of all the ancestors of the mammalians. This repetition has been retained, even while individual groups struck out on new ways of development involving their being carried longer within the body of their mothers.

However striking this mode of growth may be, the weight development of the human offspring, when measured against that of all other higher primate forms, is no less so. Newborn orangutans, as well as gorillas or chimpanzees, weigh on the average somewhere around 1500 to 1800 grams; on their part, the human offspring reach about double that weight, averaging between 3250 and 3650 grams. This is not a matter of the developmental period; our gestation time of 260 days largely equals that of the anthropoid apes -- if we take 235 days as the norm for chimpanzees, then at this time the offspring of a human already weighs more than 2500 grams. If we take the top weight of a newborn chimpanzee (2300 grams), then we must compare this to the human product of 4000 grams. When we compare them with the anthropoid apes, the human offspring produces about double the living mass during the same period. When we seek to understand this contrast by examining the different possibilities, we are left in the end with the dependency of the body on the species-determinate brain development. At the moment of birth, our brain weight amounts to three times the weight of that organ in the anthropoid apes at this point in time. This achievement during the uterine phase may thus be quite essentially conditioned by the formation of a very much greater brain to which the body mass must somewhat correspond. The fact that the total weight of our newborn does not total three times the mass of the newborn children of the anthropoid apes must, it seems to me, be connected with the strict limits which the mother's system places on the size of the child at birth.

The Extra-uterine First Year

If we start with our knowledge of the individual development of the higher mammals and then base our theoretical attempt to make a conceptual model of the conditions surrounding the birth of an "animal man" on that knowledge, the peculiarities of the first years of human life after birth spring vividly into sight. Instead of a complete maturing in the monotony of the mother's womb -- and also in its safety! -- to the degree corresponding to that of the birth conditions of all highly evolved mammals, human children are cast into the world a whole year earlier, "brought into the world" as the expression says so clearly. We wish to take this exceptional case very seriously. The essential characteristics of human behavior first assume their definitive form toward the end of this early extra-uterine year, and this primary informing can succeed fully only within the framework of a rich social environment; these facts show how much this kind of development, which is obligatory for our human kind of existence, belongs to our peculiar form. There are very sound grounds for designating this first year after birth as the "year in the social womb". Indeed, in our case, society assumes the task which is otherwise left up to the body of the mother -- a task bound up with the formation of essential peculiarities of the conduct of our mature existence. These are, once again, the assumption of an upright posture, speech using words, and the perfecting of our rational relationship in the world. In our hypothesis concerning the origin and the rise of our form of life, the growth which takes place during this peculiar first year must therefore have an important place.

As its contribution to this undertaking, zoology investigates the history of our species. An hypothesis concerning the evolution of our ontogenesis presupposes a careful search for a synthesis of available data; once that has been completed, that hypothesis itself can then be used to strengthen the basis of a developing anthropology.

There are growing indications that the separations of the lines which led to the anthropoid apes must have occurred relatively early in the tertiary period (see above). Even if we leave the number of millions of years open, we still take it as certain in our calculations that none of the anthropoid apes of today is the precursor of the genuine hominids. To this primarily restrictive judgment we must join one out of comparative morphology: The contrasts in the development of the individuals of each of the groups are so clear that they, too, make a long separate development more probable than the reverse.

Therefore, what we assert concerning the ontogenesis of the anthropoid apes, (*pongidae*), does not involve us in certainties concerning the "pre-hominid" process; rather, our assertions are concerned with analogies to what we must refer to as "para-hominid". The procedure which explains the peculiar characteristics of the ontogenesis of the anthropoids as comprising the first steps in human evolution must be used with extreme reserve since this might tempt us to explain any number of other things in this way. Also, we do not know the ontogenesis of the primates which we assume to be the ancestors of the hominid lines of development. Perhaps that ontogenesis -- which we *know* we do not know! -- already manifested special characteristics *vis à vis* the forms known today, forms such as the macaques, baboons, green monkeys, or gibbons, and which were important for further evolution in the direction of human kind. The reservation which is urged here is not intended to detract from the significance of the intensive general investigation of the ontogenesis of all apes; the traces of that ontogenesis help us to understand the way to humans better.

We know that the majority of old world apes differ from the anthropoid apes in that in the former, the very close dependency on the mother lasts only about one third of the time that is manifested by the anthropoid apes -- about one year, as opposed to about three years. We know neither when in the human line, nor in which outstanding characteristics, this lengthening was reached.

The same holds true for the evolution of the brain and for the correlation of brain and body size at birth. Although the paleontologists stress that there exists a certain probability that the higher development of the brain was completed first after the assumption of upright posture, still, we must not lose sight of the tentative character of every assertion expressing our suppositions concerning the mode of ontogenesis.

If the contemporary analysis of the organs of speech makes it appear not altogether erroneous to argue for a true speech capacity for the Australopithecines, still, such an hypothesis must be tested further with the greatest care and scrupulosity. One decidedly ontogenetic phenomenon -- the beginning of the descent of the larynx, which is rooted in the history of the species and which is decisive for the emergence of speech -- is, perhaps, forever withdrawn from the observation of paleontology, but it is presumably very closely dependent on the fully upright position of the body.

The Phenomenon of Intellectual and Spiritual Behavior

The investigation of the origin of mankind has two mutually supplementary tasks. First, since it starts out with the certainty that our form of life originated only when it took its first steps out from animal stages, that investigation must point out the points of agreement between our form of life and that animal manner of life and development. However, it must no less carefully describe the disagreement, i.e., the difference of the human world-relation -- and it must do this without first considering whether or not that difference can lead from the difference found in the present-day state back to animal origins. This second task is often neglected, and even the expression of any interest in contesting any of the details of the theory of evolution is viewed with suspicion! But, the fact remains that we must see humanity *as it is given*, in its full peculiarity, in order to judge what it is that the theory of evolution has to clarify if it wishes to describe the origin of mankind.

The examination of correspondences and differences brings to light a variegated mosaic of distinguishing characteristics whose origin can be more or less clearly outlined. However, isolated by an immense span of time, that origin remains hidden in its particular details. Investigations into the preconditions for speaking, for vocal utterances, have yielded a rich harvest of conclusions, (see above). The incapacity for speech among anthropoid apes has been connected to the structure of their central nervous system and, in light of this peculiarity, the intellectual and spiritual form of life appears to

be localized in the brain -- in so far as a special instrument for it has been sought out.

Our kind of existence, however, is anchored as a predisposition in the general structure of our germ cells -- in the plasma of the ovum as in the genetic structures (genome) of the nucleus of ova and semen. Our comparison of the development of humans with the other mammals -- especially, indeed, with our nearest relatives, the primates and the anthropoid apes -- leads us again and again to characteristic differences which are all too gladly pushed aside when the matter of proof of the relationship arises; but these characteristic differences attest to the particular path of humans even in the earliest phase of ontogenesis. What is more, we are presented with the increased growth of the human offspring until the end of the first year after birth. How many individual hereditary factors had to be combined for this particularly human event to be able to take place? We have here the accelerated growth rate of the brain, but also the holding back in the growth of the lower extremities somewhat after the sixth month in the uterus of the mother -- a braking which is then succeeded by an acceleration in the second half year after birth. We must not forget the slowing down of our growth from the second year of birth until puberty. This process hardly makes sense in any other context than to create possibilities for speech and to strengthen social incorporation. And in childhood and youth, that early age of wonder which lasts until the 8th and 9th year, is separated from the unfolding of the rational elements which occurs with puberty. All this certainly constitutes an altogether special complex of hereditarily laid out coordinations. The first half of this long period is spent in the service of our familiarization with our naive original world picture, and the concluding years serve to secure that child who has arrived at maturity within the secondary world of rational insight which is erected by our understanding.

The formation of an organ no less central to our upright posture than the spinal column reveals that the peculiarly human is deeply anchored in the very earliest events associated with the human offspring. Indeed,the properly upright posture first begins toward the end of the first year after birth, and it is realized through the working together of the child and its group under the stimulation of imitation and encouragement; but the structural necessities

were prepared long before. Even in the second month of fetal life, early endowments which serve the strengthening and inflection of the lumbar region of the spinal column, i.e., the perfecting of the later promontories, arose in the pelvic region. This occurs at a time where, according to the views held by many -- views taken from the early literature concerning descent -- the human embryo should still stand at the stage of development of apes. No one simply denies that there are repetitions of steps in the history of a species; but early factors which are effective *vis à vis* the particular development of a species are superimposed on these repetitions. This holds for the early endowments of the trunk of an elephant or for the very early separate path of the formation of a whale, exactly as for the deep separations which, in the case of human beings, have long since prepared for intellectual and spiritual development.

The peculiarity of the first, extra-uterine, year which has been stressed in our survey appears in this complex relationship as an essential trait of human evolution. We see one relation which must be examined in particular, namely, that relation which exists between the contracting of the period before birth and the realm of the social world in association with which the organ of the childish relation to the world is brought to maturity.

In the case of all higher animals, no one will discount their ability to learn or the operation of a group tradition. But the great ability we have to direct our interests "arbitrarily" toward each and every thing; the great gift of representation of what is spatially and temporally absent to the perceptual field; our astonishing achievement that we, facing ourselves, thereby permit eccentric behavior to occupy the place of the concentric animal being (Helmuth Plessner) -- all this must, from a very early time, have been already prepared for in yet unknown structures within the central nervous system. We can characterize the life form of animals, even the highest forms, as "environment-bound" and ours as "world open"; for all that, we still do not wish to be captivated by the illusion that we thereby signify two wholly distinct ways of living. It is a matter of accentuation. I know about the objectively observable behavior of animals as I know about human acts which are essentially bound to their environment. However, in all our knowledge about the deep agreements which bind living things together, we must never

permit ourselves to forget the gradation in the richness of the world-relation. To point to this relation is the immeasurably important task which complements our search for those points of agreement which bind our form of existence together with the existence of all organisms.

Biology does not seek the "spirit" which can be separated from soul and body. It seeks the organic materials of a special world-relation which, because of historical considerations, has here been termed "intellectual and spiritual".

Part III[1]

Interpreting the Form-structure (Gestalt) of Organisms

In my two previous articles, I tried to give an account of how a biologist's concepts are changed in the course of his work and to point out that people who are not involved in the biologist's work remain unaware of such transformations. Transformations in the concepts of the working biologist are of the greatest significance to us because they concern the image we have of nature and, as an extension of this, they vitally affect our way of viewing the realm of living things.

All these researches are working to attain a new understanding of living matter, and, if we consider them altogether, they are in the process of forming a *new* image of the organism. We shall try for what will be at least a partial understanding of this new image and we will begin this attempt by looking at the most widely known subjects of biological research, namely at the reproductive system, hormones and ferments, at muscle activity, nerves, glands, etc., as well as at sexuality. The organism has always been simply regarded as a whole in all these studies.

When, to take an instance, we study the elephant, we begin merely by considering it as one of many kinds of mammals and not as that singular form-structure whose existence presents us with so many questions. The ostrich, the one-celled amoeba, and the fruit flies, (*Drosophila*), are all bearers of functions, and studying them therefore helps us both to understand the mechanisms for and the interdependency of performances which ensure survival. The results of such research enable us to control

nature's processes, and for many scientists this is the most important goal of their work. These research methods have tremendous effects on what goals were pursued by medical research and biotechnology, and thus also on healing and other human concerns such as the intensification of plant and animal breeding and the fight against harmful life forms. The significance of this must be kept in mind when we try to comprehend where it is that contemporary biology stands when it considers its goals and aims.

The dominating influence which has been exerted by these research goals and aims has had a result which, among all the others, has been almost unnoticed, and which, precisely for that reason, is of all the greater consequence. This unnoticed consequence is the complete absence of the living reality of the organism as a totality, our complete neglect of the form-structure, of the appearance of the organism and of any experience it might have -- and, of course, our consequent neglect of all the problems that these matters should bring to our attention. It is true that very many characteristics of appearance are receiving great attention even today, but ultimately, the questions asked are what determine where we will direct our attention. In the case of hormone research, for example, the exterior characteristics of the organism are the main indicators of its inner experiences; they are a kind of gauge for hidden processes, and they are often used as test objects for what is considered to be biotechnically important issues. It is not studied for its own sake. Similarly, modern genetics considers many phenomena principally as testimonies to the effect of hidden genetic facts. The possibility of gaining insight into the mechanism of genetic processes and the way mutations take place are viewed as being of greater importance that the resultant phenomena themselves. Now, although the examination of structural characteristics is being pursued along various lines, it still remains a fact that the enigmatic character of the oneness of a living structure is no longer considered a problem requiring research to solve.

One unsettling facet of developments which have taken place during the last decade is the fact that one of the greatest enigmas of biology, the form-structure of organisms, has been plunged into oblivion. As a consequence, the change taking place in precisely that area of thought is all the more important. It is indicated in a number of different ways. The most

devastating consequence of our rejection of this enigma is the fact that, instead of evaluating the animal body according to a natural order of values, we have ordered on the basis of a scale of *practical* significance. Metabolism, development, and reproduction were finally given the highest ranks within this general scale of practical values -- and this is only proper when we consider the splendor of their successes in medicine, in human life. The one cause for regret is that for innumerable people, among them scientists, these functions assumed the highest rank in the scale whose gradations are calibrated in order of value within the *vital* order. Thus, the way we have evaluated processes in the order of their rank in a scale of practical value in relation to our research has become the value scale for nature as well!

When it was viewed exclusively in this light, the animal was only seen as a mere mechanism designed to seek and ingest nourishment in order to preserve its own inner systems. It is thus not surprising that we have finally reached the point where a botanist almost apologizes for mentioning the beauty of flowers, while the zoologist does the same when he is occasionally moved to speak of the richness of animals' patterns without referring to protective or warning costumes or signalling roles. But such ways of considering things is viewed as an excursion, as an overstepping of science into the region of the poetic -- something only permitted on Sundays and holidays.

Let us, therefore, once again try to perceive the form structure of organisms, or better yet, the *entirety* of their appearance, exploring every possible meaning of the term, "appearance".

When we do this, we see at once that even those very life-sustaining functions, which help the mechanism to live, provide services beyond the primary set of tasks they perform. Let me mention a few examples. The movable portion of the outer ear of mammals has as its primary function the localization of sounds; as such, they are organs which perform a function which is basic to the life of the animal. It is, however, equally clear that, in the case of more highly organized animals, this movable portion of the ear also serves in the task of communication; what is yet more, in those cases where a species is socially highly developed, the movable portions of the ear serve to communicate to others the inner emotions of an animal and they

thereby help to regulate communication among members of the same species. We find upon further examination that the organs of hearing are sufficiently developed in regard to size and form-structure or color and patterning, and even in regard to peculiarities of hair growth that they give rise to unmistakable characteristics which help to express a picture altogether peculiar to that particular species. In all these particular points, they far exceed the requirements of structure formation which is merely adequate for organic preservation. This *expressive display* of the picture belonging to a species permits us to transgress a significant frontier: namely, it may still be correct to make definitive statements concerning the elementary functions once we have crossed that frontier, but those statements are not sufficient to explain what it is which we in fact meet with on the other side of that frontier. Every organic form-structure transcends elementary necessities.

This transcendence! Precisely these edgings and ornaments attached to the elementary natural form poses further questions to the biologist. Nor are those questions answered by means of the methods used by functional research. But this should not surprise us since the methods of physiology were never sought out as ways of solving the problems raised by such form-structures. But, even if a method can only produce an answer to questions which are properly addressed by just that method, it would be a mistake to suppose that the mere posing of biological questions could result in the creation of a group of answers.

The work of morphology, that is, of the exploration of form structure, begins once we have crossed this frontier. Morphology is a way of working which seeks to explore all the characteristics of the living form, and not only those whose survival value can be examined in physiological experiments. This means that morphology is not just an introductory stage for other biological studies; it is not just a primer meant to present a catalogue of terms. Rather, it is one of the enduring -- because always revitalized -- tasks of any research into life. What we know concerning living things at any given stage of scientific development can only be expressed when the various directions which research takes all come together.

When morphological studies are prosecuted within a wide horizon, they can widen our view of the exceedingly limited significance of living

structures which we have taken from most of science, and thereby we abolish the compartmentalization of various attributes found in living organisms. Morphology will not simply claim, for instance, that this or that characteristic is a social trigger for this or that function; rather, it will point out that the triggering of a function can be one important role of a characteristic, but that we can never exclude the possibility of wider roles and additional interpretations. Indeed, a riotously colorful flower may very well be the trigger for an insect's visit, but it is also something else, for it also comprises expression of a cycle of transformations taking place in its form-structure; and, in the richness of its development of its display, it is the highest formal manifestation of the dynamic being which is present in this particular plant here.

It is in this way that morphology points to a "both this *and* this" in the meaning and sense of living form-structures. It presents us with the degrees and levels of coordination and usefulness which we find among the individual characteristics of form-structure -- and in this way morphology points to degrees and levels of meaning to be found in those form-structures.

Degrees and levels of meaning and sense -- a fact that has been remarked all too little. An age of slogans is determined to simplify and to bestow sturdy, conventional meanings on things. We, on our part, would like to reconvene in order to reconsider the complexity of reality once again. I would here like to consider a complex form such as the antlers of a buck.

We are struck at once by a peculiar circumstance. In a family of animals including the Tibetan musk-ox and the Muntjak, distant relations of deer, we find a rare formation alongside complicated antlers, similar indeed, to a multi-armed chandelier. The many victims of the mating battles in which both opponents perish, exhausted and with entangled antlers, bear witness to the fact that what we are faced with here is an elaboration overlaid on a basic structure with its own basic functional value, and it also shows that we are faced here with a sense of the concept, *domination*, which is clearly a new sense. I, myself, have tried to bring it into high relief by referring to it as comprising the representational value of an organ.

Let us here recall the rule, "both this *and* this". The representational meaning of antlers does not imply that we should no longer view them as

weapons. Rather, one sense transcends the other and thereby creates a different level of meaning.

Antlers are dependent for their development on hormones secreted by the reproductive glands, i.e., by the testicles. The development of the antlers can be stopped by early castration. Hunters have also reported all kinds of misgrowths in buck and roe which are attributable to injuries of the testicles. They also know that the structure of antlers becomes weaker and more dagger-like in old-age. An aging buck may therefore suddenly become a dangerous "murderer" to use a hunter's term. But the role of antlers as the mark of the individual has, at this point, not yet been mentioned by us even though many observations testify to the importance of the head decoration in the life of the group. One of the most important of these observations is one mentioned by the animal psychologist, Prof. Hediger of Zurich: The throwing-off of the antlers has a shock-like effect, one which depresses the buck and makes it retire from any social activities for a short time.

Biologists have observed another strange thing as well. In the reindeer, both sexes bear large, branched antlers. A castration experiment has shown us that these antlers of the reindeer are not influenced by the hormones of the reproductive gland -- which means that the system of genetic factors which causes and determines the formation of antlers has here therefore been released out of the matter comprising blood. Instead of being an indication of gender, the mighty head decoration has, in the case of the reindeer, become a full characteristic of the species. This of course does not preclude its value as a weapon; rather, it indicates another level of meaning to us, one which is beyond this purpose as a weapon.

The meaning of such an antler structure is being investigated in the most varied studies being carried out by different biologists. And, in fact, the many roles that the antlers play in a deer's life, as well as its many levels of significance, have been verified by these studies.

Instead of talking of a buck's antlers, we could have reported on the tusks of elephants, the peacock's wheel, on the spider's net, the crane's dance, or the bird's song.

And so, *a new assignment of values* -- a new scale of worth -- is slowly being shaped within our reflections on the living, being because of these

studies and discussions of researchers. According to this new ranking, the organism is a part of an unknown reality the individual pieces of which we strive to recognize by constantly posing different research questions. To take an example, we are aware of substantial interdependence in those processes which ensure nourishment, survival, reproduction, and evolution. We also have grasped many facts which testify to the change in species during the course of the earth's history. But it is becoming more and more apparent to us that the connections which research has revealed are in each case only a partial explanation of what takes place in the plants and animals around us. We today suspect that these complexes have as their goal *more than* just the preservation of the species but, what is of equal importance, that the construction of a world of experience has been translated into reality, that in front of us are inner realities experiencing their worlds, realities which have created individual worlds of the most varied intensity of fulfillment. We can only suspect that, among many other things, the form-structure of appearances is also a device for communicating this inward reality. Our new grasp of the organism makes allowances for the urge to survive, for the fight for survival, but it sees both the striving for survival and threats to it as a part of a much larger whole. Only when the whole is conceived of as an immensity can there be any sense of the extent of the area investigated by the research biologist.

To us, the work of the life sciences seems comparable to the exploration of a huge fresco whose size we may suspect, but of which we only know small parts. We fill the wide, unknown spaces of the picture with additions we think are proper and we time and again conceive new designs which are intended to organize the things we do know into an understood whole. Nobody knows how far we may sometime reach in the course of our attempt at understanding. But, in our work we should always preserve the general insight of biological research: namely, that the organism always represents more than what we can explain today.

CHAPTER VI
Endnotes

1 "*Der Mensch im Felde der Evolutionstheorie*," *Meyers Enzyklopädischem Lexikon*, (Bibliographisches Institut: Mannheim, Wein, Zurich: 1971).

2 "*Lebensforschung in unserer Tage*," *Universitas*, Heft 3, April, 1955.

PART IV

THE LIVING FORM-CONSTRUCT

Introduction

In his essay, "Goethe and the Concept of Metamorphosis," we find Portmann comparing and contrasting the workaday world of the analytic biologists who use biochemistry and biophysics to investigate life-processes with the morphologists who start with whole, living, individuals; he speaks of the former scientists as working "backstage" and of the morphologists as viewing the world of living things from "out in front of the stage." He says:

> "Let me here compare the richness, the manysidedness (sic) of events, within the living being with a magnificent drama being played before us.
>
> If I wish to be completely satisfied in my desire to grasp this drama in its entirety, I must seek out at least tow entirely different positions: backstage, that is, behind the proscenium, and also a position out in front, as a spectator....
>
> Now, backstage, I become acquainted with the paraphernalia, the technical procedures, which make a fully adequate production possible -- the workings of thunder and wind machines, no less than theatrical contrivances which make even ghostly apparitions possible.
>
> Entirely different rules govern out in front of the stage; here we are concerned with relationships between human beings. I must know the language; I must grasp word, sense, and gestures; I must yield myself completely to appearance and, if the performance is to be successful, I must know absolutely nothing of the mechanics which make all that possible: by no means can I know how it is arranged that Hamlet's father appears credible as a ghost."

In this fourth, and final, part of this present work, we shall see the work, we shall see the work of a theoretical zoologist of the highest eminence in which we are challenged to take seriously *the reality of appearances*! With

this development, the reader will find what is perhaps this first serious challenge to the tradition beginning with Galileo, Descartes, and Locke, made by a professional zoologist of great repute, to begin truly scientific and philosophic inquiry with wonder and vision -- rather than with "universal doubt" and a universal rejection of the world of appearances as merely symbolic of neuroendocrinological changes of state.

CHAPTER VII

WHAT DOES THE LIVING FORM MEAN TO US?[1]

Although many practitioners of the fine arts are now consciously turning away from natural forms, the question of the sense of these living forms, of their meaning within our spiritual world, can still be posed.

When we ask ourselves with what spiritual analog to our sense organs we approach living shape, how we conceive of it and grasp it, we realize both the extent to which our sense of these shapes has grown dim, and for just how long this has been the case: only then do we realize the extent to which we have lost the living form as the symbol that explains both the course of earthly events and our human fate; and we realize that we have lost this sense even though for centuries that symbolic interpretation governed the representation of natural beings here in the West. Then we see the interpretation of living nature which gained ascendancy in the early Middle Ages, and which for centuries thereafter assigned a high rank to beasts because they provided similes which helped us to understand our lives. It is that interpretation in which the dove symbolized the Holy Ghost, sometimes even the Church, and in which the individual phenomena of life were perceived to have a hidden relation to the life and sufferings of Christ and to the pre-ordained course of Providence. To the faithful, the helpless lion cubs were not merely blind and immature newborns who could not survive outside their "nursery"; rather, echoing extremely ancient notions, believers attached much more significance to the fact that the lion first awakens its young to life proper some days after birth and that they come to see first after a period of blindness. In this view of the world, man also first comes to see in the true sense of the word only after his life on Earth. This is what the portrait of the young lions in the stained-glass windows of the cathedrals said to believers; and the images of the pelicans, who, shown nursing their young with their own blood, testified of Christ whose death was his self-sacrifice.

But all these interpretations of animal shapes belong to the past. The symbolic interpretation of nature as the mirror of a higher spiritual world has long since been lost, even where the faith out of which they arise is still alive. Science transformed the picture of living things four hundred years ago, and a new attempt at understanding organic shapes has been resolved upon under its influence: that is, we are going to explore the possibility of viewing plants or animals, in details of their forms no less than in the totality of their appearance, as bearers of a vital function which contributes to the presentation of the individual of its species. Success in realizing this goal makes us satisfied with our understanding, with our insight into interrelations, and that sort of satisfaction is so important to many men that they are completely contented by that clarification. As a consequence, educational policy came to control how we were trained in a particular way to understand organisms; consequently answers which we easily obtain after little effort lead us to a badly one-sided judgment upon all life around us; in the long run, what is more, that sort of inquiry also leads us to corresponding judgments upon our own particular being as well.

Rational investigation presently plays a role which results in its complete domination over all other modes of understanding: above all else, it seeks to demonstrate the relation between form and function. This domination gives rise to certain privileged organisms which stand in high relief. These display characteristics strike us as being immediately intelligible in terms of their function; so, for example, the streamlined form of fish, of dolphins, or the dynamic form of running animals, say, antelope or greyhounds. A functional interpretation has become more and more inclusive, and, most recently, it has come to dominate our entire view of living form. Indeed, we tend to think that only functional value points to natural form. Thus, for example, coloration is seen in its role as signaling; it appears either as a sort of natural semaphore, or it is observed as a cloak which camouflages, as a defense mechanism which works by concealment. In the plant world, the display of blossoms appears first and foremost as an instrument of allurement which is directed at pollinating insects and birds. Our museum exhibitions, our popular press, our school texts; all these try to impress upon us precisely this meaning of form. Nothing is easier than that.

There has been an idea in the air for some time which owes its success to Darwin's theory of descent. According to this idea, selection chooses out of newly arisen characteristics, (all of which are equally undifferentiated for it), only those which favor one form and annihilate another in the course of the struggle for existence. This view of natural selection and of its power has provided powerful confirmation to the functional interpretation.

Now, if we only view form-selection as a vehicle for functions, no one doubts that it comprises an important part of living reality. It is not without good reason that both general physiological research and human medicine are erected on the foundation of this relationship between form and function. The classical division of organs into those concerned with nutrition, breathing, excretion, movement, reproduction, the relation of the individual to others, etc., gives rise to this way of thinking, and it has provided us with ways to understand an extensive part of living things. Some time ago, however, a school of thought arose within morphological studies which professed to be "functional morphology", and which then claimed that it alone pursued the ultimate goal of all the work undertaken in morphology! Sometimes this thinking has led, (I am almost tempted to say, "fortunately"!), to such excesses of utilitarian interpretation concerning function and utility that even the least insightful investigators have clearly realized that they have gone too far. Prior to the last two centuries, such excesses were the result of a theologically oriented biology which generally attempted to recognize in living things wonderful ordinances of a creator; in our time, it is primarily the search for selective factors, (in the Darwinian sense of the term), which constitutes a similar, although oppositely sensed, extreme. This extreme way of thinking leads us entirely to ignore the great dominions of reality which are neglected because of the procedures we today use to investigate reality.

The interpretation of the organism as purposive form often finds powerful support in our aesthetic experience. For instance, we find that something about the shape-producing power of a closed form affects everyone (which, incidentally, psychology has also noticed), and living beings formed in this way force themselves on our unquestioning awareness, imprint themselves clearly as shapes, and thus at the very least powerfully contribute to our concept of living things -- even if they do not ultimately and

definitively determine it. Such closed shapes are exemplified in the already mentioned streamlined forms of fish. Equal in rank to these -- indeed, we think of them as being even more powerfully effective -- are the flight forms of birds. The sharpness of outline, the detached, silhouetted being of the shape in space, the conquest of heaviness in the form of flight -- all these assert themselves so as to strike us with great power. But still other laws of experience co-effect these preferences, such as, say, our inclination toward certain proportions. That one called "The Golden Mean" comes to mind when we consider the force with which we are impressed by the quadratic forms as such.[2] In this way, a very broad group of privileged shapes have arisen: These are the "noble" animal shapes which, we must remember, appeared over and over during certain periods of classical art. It is the proportion of the horse or of a stag and it is the form of the greyhound which Duerer, as well as Pisanello, studied. These force themselves on our awareness entirely differently than, say, the form of a salamander or of a toad.

When aesthetic experience associated itself with the way of thinking which is characteristic of technical understanding, namely, a way of thinking which presents few difficulties for anyone, we were led to an interpretation of the organism which connected our feeling for definite proportion to our satisfaction with the functional sense of form. Thus, we are not surprised that the just mentioned group of especially favored forms authoritatively determined the picture of living things for innumerable men!

We can see that this technologically oriented thinking can become quite powerful in its role as a definitive movement in the development of art. All we must do is consider the example we have at hand from the end of the 19th century. At that time, the natural form was recognized as the principle motive force behind the yearning of that time for an overthrow of the all-pervasive stagnation of the architectonic experience and forms of the day. The natural form had been the great stimulator in the revival movement since John Ruskin, and for a period it played a fruitful role in the *art nouveau* style. Ropes of algae and leaf-shapes, strands of hair and ornamental forms of lower animals such as polyps and medusae -- these were then discovered

to be rich sources for the production of form, and they were exploited until their visual sense was exhausted.

As a consequence of this exhaustion, a physiologically oriented thinking in architecture began to prevail which was intended as an extreme case of the idea of function. According to this thesis, form should be the strict expression of a performance -- as it is in nature. This thesis became the war cry of the innovators. Even before the turn of the century, the American, Louis Sullivan, gave the formula: "Form follows function." This became the catch-word for many of the reformers among the architects. This physiological concept led, above all else, to the devaluation of ornamentation. As a consequence, it gradually led to the rejection of all the expressive value of the outer appearance of buildings as well. "A facade": since that time this term has come to refer to a negative subject, to the gross, forbidding example of empty ostentation, to senseless veiling of the living function. This physiological thinking then led on to the further broadened implication that the act of building must itself be determined completely in the same way as it is for the organism -- from within outward, beginning from the support functions. The strict realization of this principle requires that the form of the outside be presented as coming from inside, from itself -- as a pure being rather than as a false appearance. Today we must realize how the one-sidedness of this principle misinterprets natural forms and how widely it threatens to divert us from a real understanding of living form.

If the vision of the architects and the conception of life given us by the influence of biological work have been compelled -- specially in physiology -- to move toward a heightened stress on function, it is presently all the more incumbent upon the life sciences to examine their own proper object again, to ponder, that is, whether the mode of investigation which biology itself produced during an earlier phase is really the most important, or whether, as a consequence of that mode, meaningful aspects of living appearance have not wrongly been forgotten. I am in hopes that my present attempt might help us to entertain such a possibility seriously.

We would do well at this point to leave the privileged forms in our reflections, and to continue by turning our attention in the direction of life forms which, for some time now, have ceased to occupy the full center stage

in the public mind. Such strange organisms are found in considerable number within the so-called lower animal world. There we find, for instance, sea stars, and sea urchins or sea anemones, as well as jellyfish, which are able to draw our attention to themselves. As of the present, however, no one has even attempted to explain the multiplicity of coloration in the visible image of these animal forms by an appeal to some special adaptation. Some of them present an appearance which is quite riotously colored and is neither protective nor the means of species identification. They do not serve to locate sexual partners, nor are they at the service of other sorts of relationships between individual animals. Thus we discover laws which, although they are especially striking to us in these instances, will nevertheless also be found to apply to other life forms once they have come to our attention. I shall take as an instance a large, beautifully colored sea anemone with many feelers, one which is found in many exhibition aquaria. Looking at it very carefully, we discover that, in the thickened ring of the tentacles, two of them are strikingly marked with color. What do they accomplish? They serve only to delineate the single plane of symmetry of these animals whose structure appears to be only radial. I search further and I find yet two other pairs of tentacles which lie in quite definite planes with respect to the primary pair; and, once again, these are distinguished from all the others -- not so richly displayed as the two which act as a cardinal pair, but still, more luxuriantly than the rest. So, in this way, the inquiring glance leads to the discovery of a series of degrees of display in strict geometrical order: ornamentally effective formations which reveal absolutely no functional value but which are merely expressions of the inner structure which is characteristic of nothing useful! Here we find no unique function in the sense of life-maintaining accomplishments. Of course, this peculiarity was known rather early, and this, along with all such characteristics, were designated as "functionless". In periods of high evaluation of performance structures, such functionless ones were simply dismissed and no further notice was taken of them. It was remarked from time to time that they might have systematic worth, that is, they help us to recognize the kind of animal under consideration; they are useful to us in our taxonomic attempts.

Once we have really looked at the "functionless" characteristics as a reality, we discover at every step an incredible richness in them. Just a glance at the store of wonders to be found in plants illustrates this. We are in agreement, and scientific research has demonstrated in the face of all doubt, that blossom display is determined primarily with regard to the workings of the eyes of pollinating insects or birds. If, however, we test the blossom seekers through experiments using artificial models of blossoms, we find that although many of the blossom characteristics are necessary to entice the pollinators, and are thus necessary for the completion of the pollinating act, still, very many of these characteristics of the blossom are irrelevant when regarded in the light of function, and therefore, they have no more than systematic value. This mere system, however, includes especially many particulars, and among these is what appears to us in the blossom as especially lovely and appealing, what the particularly unmistakable display of poppy blossom, of the carnation, or the wild rose, gives to appearance. Further, if I immerse myself in the green world of leaves, I meet with the same thing. To the blossom seeker, greenery is pure background. The shape of leaves has no functional value here. For the grazing animals, that same greenery is the source of nourishment where, once again, the leaf shape as form is irrelevant. On the other hand, the morphologist will very often begin with the shape of the leaf; for him, they contain very valuable criteria of genus and species, and a look into the green profusion of leaves opens to the artistic observer a storehouse of wonders of very intimate beauty. But still more: if I take pains to distinguish the leaves of a plant in their correct sequence from the bottom up to the region where blossoms are found, that is, if I distinguish them in their order of occurrence,then we all will be amazed to find how consistently the leaf outline is transformed from the earliest, simplest form, over a variety which unfolds and ends in a later second simplification next to the blossoms.[3] You all know that Goethe gave his deepest attention to these appearances and that he summarized them under the name of "Metamorphosis": "change of form." But this change of form is part and parcel of the great phenomenon of which we just spoke, namely, of the expression of an inner state of being of the organism.

We have previously decided, (and we continue to think this way), that we are not going to characterize this sort of property as a function. That term "function" finds its proper signification in a narrower universe of discourse, namely, in one which is concerned with the individual's capability for preservation; thus, we intend both to lay stress on this entire universe of form-phenomena and to classify it under a special designation, that of self-presentation. Once attention is focused on this self-representation, then a focused study of living form reveals as unforeseen wealth of such elemental forms, and it finally leads to a proper reassessment of their value. For, what up to now has been designated as being properly in the periphery of attention because it is functionless or "merely systematic" suddenly becomes a central phenomenon. It was considered as merely subordinate as long as self-preservation and species-preservation were ranked as the highest properties of living things. However, the organism is not only there in order to preserve itself for a longer or a shorter time. On the contrary, the preservation of the individual and the species serves a greater purpose; preservation of both individual and the species preserves precisely the rich existence of manifold forms, and all of them are, without exception, more than bare carriers of preservative functions.

Are our own strivings not rooted in a deeply hidden impulse which is beyond that of the mere span of time of our own existence? Even when we struggle for our existence, how passionately we long for freedom, for liberating play, for form which has its purpose beyond mere necessity! Such strivings lead us, and we follow. Whoever thinks through the problem of living form will conclude that unknown powers which are akin to something in himself manifest themselves even in the form-production of living things. These powers point far beyond the necessity to live for a long time; for they reveal themselves in the realm of color and display, in the wide variety of behavior and in the song of birds. These phenomena are never explained in their richest manifestation through the demands of preservation. This is precisely what is demonstrated by that experiment which showed that many form-producing structures which work together to give us the final lovely picture we have of the butterfly's wings are nevertheless functionally

superfluous. However, those form-producing structures are here -- in abundance!

We discover the expense incurred by the organism for self-representation; we discover that living forms, inside, build according to rules which differ from those which they use to build their outward appearances -- that is, we perceive that in nature a façade has a certain value and that appearance is not a deception but an element of manifestation and, in particular, of the manifestation of a being whose source is hidden from us. The façade -- even in spite of the continued devaluation of form both in the human domain as well as in the debates in biology -- this "expression" becomes essential again when we consider it anew.

No one denies the importance of the work concerned with preservation in the game of life; it is also present in the organs of appearance. Still, prior to all functions in the service of bare preservation, prior to all this sort of activity which has gained so much attention, we are faced with the straightforward appearance as self-representation in the living being. And thus, time and time again, the fathoming of form leads beyond the realm in which research shows us the structures which are merely functionally significant. Presupposed by a comprehensive morphology is the insight that every appearance of living things must be viewed within the widest of intellectual and spiritual horizons. Each plant and animal, no less than we ourselves, must be experienced as an incomprehensible way of being which is grounded in the mystery of reality.

However, our concern with the significance of living form not only involves a deepening and enrichment of our own experience, it is also a matter of acquiring knowledge in order to strengthen our sense of responsibility with respect to the foreign forms we find in nature. Indeed, it is not our goal merely to produce anew a true respect for natural forms, insofar as they are a source of stimulation in the realm of artistic creation; for it is presently a question of the continued existence of splendid life forms whose every survival is nowadays generally threatened -- indeed, even their bare existence in the wilderness is threatened. We today face the difficult question of the right to live of all those things which we ourselves could never

create. This gives rise to a new international legal issue of unforeseeable dimensions.

When someone succeeds in taking note of his developing relationship with living things, he then becomes aware of a new feeling of the magnitude of the mystery that every organism which confronts us also exists in the world with us, of a feeling which, even if we only attain to it intellectually, opens up for us an intimate grasp of our own being.

Some time ago, at the beginning of the century, a great teacher of aesthetics, Heinrich Woelfflin, ventured this assertion concerning classical art: the proportions and masses sought after by classical art have their legitimacy in the rationality of nature, not in a capriciously willful arrangement. Nature determines a certain conception of beauty which the artist carries in his soul, a conception which is identical to the idea of beauty in nature. Hans Thoma, in whose name we are gathered together today, could have said that.[4]

We today would no longer venture to speak of natural form in this sense. It is too obvious to us that the classical view only admitted of choice from among options which were already present. It is not without reason that, even in the fine arts, we find numerous breaches into another world, whether it be the vision which speaks to us out of the work of Hieronymus Bosch, or the world of Peter Breughel, or the ever recurring new attempts which we have recently been pleased to collect under the name, "mannerism." Ultimately, however, that breach stands as a reminder of that other life which does not care to consider the carefully cultivated game-preserve of the classics. Along with Rilke, we once again know that the beautiful is only the beginning of the terrible[5] -- and it is not without reason that the world of forms belonging to the anti-classicists has been elevated so far from art in the direction of light that we can no longer experience that world as ugly. Instead, we experience it as powerful and terrible.

In our perception of organisms, we experience this power and this terror, foreign, and yet at the same time near to us. We know that all forms in which individual being is alive there, in front of us, belong to the same present as we do: both of us are individuals.

The molecular world, as the lowest level of living being, knows only multiplication and constant increase through division. There, death occurs only through annihilation from outside. Death as a law of inner development is only known by higher life -- whatever kind of life that might be. This world in which the individual and death occur is the world in which we all stand in deep union and unbreakable solidarity -- and this is the world with which, even if by lengthy and sometimes odd detours, artistic formation returns to it time and time again.

As Heinrich Woelfflin once said when praising classical art, "Nature offers us the rare good fortune to share in a greater, purer, existence."[6]

We experience nature differently in our time -- so very differently that the very creation of pictures has often entirely wandered away from natural form and permitted itself to be mastered and motivated by the play of immensely elementary powers.

I do not believe that we will persist in this turning away. Whoever is aware both of the limitation of our ability to discover forms and of the weariness which results from each and every new attempt to discover forms, and who, on the other hand, knows the unimaginable fullness of the forms of nature cannot continue to believe that in the long run the creative artists will choose to continue to join that large number who today avoid these springs of new inspiration. We investigators of nature have no prescription for the future which we can address to the creative artist. Although I do not wish to prophesy, I do however wish both to vouch for and to labor for a conviction. And thus it is that I speak of this belief in the greatness of living forms, of the depth of its mysteries which everyone comprehends who surrenders himself with open heart and mind to the might of the impression of these shapes.

CHAPTER VII
Endnotes

1 "Was bedeutet uns die lebendige Gestalt," *Neue Sammlung, Götinger Blatter fuer Kultur und Erziehung*, 6 Jahrgang, Heft 1, Januar/Februar 1166, pp. 1 - 7. (A public lecture, delivered on the occasion of the author's being awarded the Hans Thoma Medal on May 1, 1965, in Reutlingen. Published with permission of the Hans Thoma Association, Reutlingen).

2 The Golden Mean or section is obtained by cutting a line into unequal segments such that the greater segment is to the lesser as the whole line is to the greater. Zen Buddhist temples are designed on this principle. (Trans. footnote).

3 Portmann told me that he is here also thinking of the works of the Cambridge botanist, Agnes Arber, whose thought, "was a turning point in my life," *vid*. Agnes Arber, *The Natural Philosophy of Plant Form* (1970, Hafner Publ. Co., Darien, Conn.), esp. Ch. VI, "The Partial-shoot Theory of the Leaf," and Ch. VIII, "The Bearing of the Partial-shoot Theory of the Leaf on other Morphological Problems." Agnes Arber is also the author of, among other works, *The Mind and the Eye*, and *Goethe's Botany*, which appears at the end of this volume as an appendix. (Trans. footnote.)

4 Hans Thoma, German painter (1839-1924), born at Bernau in the Black Forest. His painting had very little affinity with what we consider modern style, apparently being definitively formed by his early experiences in the lovely Bernau district. His work has affinities with the early German masters, Altdorfer and Cranach, as well as with the pre-Raphaelites. His work is largely concerned with "nature". (Trans. Footnote.)

5 *Duino Elegies* "Die Erste Elegie": "...Denn das Schöne ist nichts/ als des Schrecklichen Anfang, den wir noch grade ertragen/ und wir bewundern es so, weil es gelassen verschmät,/ uns zu zerstoeren. Ein jeder

Engel ist schrecklich." ("First Elegy": "For beauty is nothing/ but the beginning of terror which we just barely can endure/ and we are so astonished by it because it calmly disdains/ to destroy us. Each and every angel is terrifying.") This translation follows MacIntyre's somewhat freely. (Trans. Footnote).

6 "existent" translates *Dasein*.

CHAPTER VIII

GOETHE AND THE CONCEPT OF METAMORPHOSIS[1]

Goethe's book, *Die Metamorphose der Pflanzen*, (*The Metamorphosis of Plants*), first saw the light of day in 1790. It was divided into 123 sections, comprising an introduction and eight chapters. None of Goethe's works which deal with living nature attain the inner unity and the intellectual breadth of this treatise. To this day, only his *Farbenlehre*, (*Theory of Colors*), is comparable to it.

Even while he was writing this work, Goethe stressed that, in the future, he would continue to be no less active in the field of natural science than in poetry. Even as long as twenty years later, however, we find him remarking that he was still seeking for a mode in which to express how he saw nature -- but at the same time, he spoke of "revealing myself, my inner nature, my way of being in a certain way." There is no reason to think that we should not keep this declaration of the extreme breadth of his purpose in mind if we wish to grasp the full significance of *The Metamorphosis of Plants*.

Our first task is to glance quickly over the variety of meanings which biology gives to the word, "metamorphosis". In the development of our life sciences here in the West, this concept primarily embraces the striking changes in form which are shown during the course of the lives of many insects and amphibia; the butterfly and the frog are precisely the examples which Goethe himself carefully observed and demonstrated in the court circles of Weimar. He had read Swammerdam and Reamur; he knew the astonishing work of the jurist Lyonnet, the *Traité de la Chenille*, which was the outstandingly painstaking study of the anatomy of a caterpillar.

Again, in morphology, the word "metamorphosis" also designates the form variations found within a larger circle of related individuals, and thus within a type. Goethe made a special study of form variation in the case of the vertebrates, but in his *Metamorphosis of Plants*, he addressed the quite

particular change in the form of structurally similar elements which are arranged along an axis -- what we today refer to as "serial metamorphosis."

This present audience does not need me to present a detailed record of the stages which led to the comprehensive presentation of 1790. You are all conversant with Goethe's decisive experiences of the form changes in the leaves of a palm in the Botanical Garden of Padua; with his deep knowledge of a primitive plant in Palermo and in Rome; and you all certainly know of the psychological state of the returned traveler -- cast from form-rich Italy back into a featureless Germany, of sunny skies exchanged for dreary heavens -- *a situation in which he sought to protect his spirit from harm by means of his intense rebellion from it.* Among the works which Goethe undertook at that time, his attempt to expound the metamorphosis of plants was the first to be completed in the year that Goethe himself gives as 1788. That work constituted for him the restorative act of his intellect which set itself the task of having to explain the particular phenomena of the glorious garden of this world by means of a general principle. That work was here cast in its definitive form.

We know the mixed response with which his friends met this great labor. That same dissention continues to the present day. I shall only cite two extreme examples of divergent opinion taken from our own time. In a address honoring Goethe which was presented in 1942, the physiologist, Sherrington, ended by saying that Goethe's theory of metamorphosis has gone the way of all unproven theories and that it plays no role in modern botany. On the other hand, the botanist, Troll, asserted in 1926 that Goethe is the founder of a scientific morphology. What is more, one of the outstanding authorities in the field of morphology, the eminent botanist Agnes Arber, has been saying, since 1937, that Goethe's botanical studies should be ranked very highly. (See Appendix IV.)

In this survey, I shall attempt to help us understand these contradictions and to clarify the significance of Goethe's undertaking for us today. Why these contradictory assessments? One fact, above all others, is responsible for the contradictory judgments of his work: out of wide realm of vegetation, Goethe limited his discussion of plant metamorphosis to a rather narrow selection of examples. He not only restricts himself to the

angiosperms, (blooming plants), but he prefers the dicotyledonous plants above all others. Moreover, the annual herbs are at the center of his attention, not the trees; and, one final important restriction he places on his subject, he only takes notice of the heliotropic, blooming shoot which reaches upward. He ignores the roots, and then goes on to justify that omission using peevish and impatient expressions.

Goethe's selection was conditioned both by his unconscious needs for a clear program and by the inherent vitality of order; if we wish to comprehend his intense pursuit of a synthesis, we must be aware of these causes. However, the botanist must reject such limitations if he really aspires to a comprehensive understanding of plant form.

One other fact: during the time period in which the *Metamorphosis of Plants* was being written, botanists had already become familiar with essentials of Goethe's results or were themselves also working them out independently of him during those same years. The central insight, that all organs along the stem can be traced back to one basic form -- "all is leaf," as Goethe put it so very simply -- had slowly been gaining acceptance since Nehemiah Grew, (1672, 1683).

Malpighi made the same pronouncement in 1671, and C. Fr. Wolff made it a century later, in 1768 The Genevan botanist, Aug. Pyrame de Candolle had thoroughly established it independently of Goethe in his *Organographie Végétale*. Still another fact, the third, is of importance here: Goethe's picture of the inner process, of the forces at work in the plant, nourished itself on a mode of thinking which the botany of that time was just beginning to overcome. We will have to examine the sources of Goethe's thought still more thoroughly if we are to grasp how greatly his vision varied from that of the botany of his time, but how meaningful that vision was for him.

We will be especially concerned with one particular aspect of Goethe's work on metamorphosis -- its mode of thought. At this point, therefore, I shall give what is in effect only a rapid survey which is designed to familiarize us with details of Goethe's picture, to survey the controversy in our time, and finally, to attempt to evaluate his book within the framework of present-day biological work.

The path leading life from seed to seed is vividly exemplified for us in the blossoming annuals, and it enables us to find a representation for the inner law of formation which is theirs: in the course of its growth, the plant's stem presents a rhythmical, clearly regular, succession of lateral structures which can be traced back to a basic leaf form. The sequence of blade-shaped leaves is then succeeded by a group of more thinly concentrated structures which lead on further from the cup-shaped leaf, the sepal, through the striking blossom-leaves, the petals, to the powdery-leafed stamens, and on to the female organ, the fruit node or ovary. Using a wealth of examples, Goethe shows us the changes of the blade-leaves, the intermediate forms from blade-leaf to blossom-leaf, from blossom-leaf to pollen vessels -- all clear proofs of the transformations of one consistent basic form.

What does this interpretation of the growth process in annual plants mean for the botany of our day? The answer to this question requires us to look at the results achieved by the old morphology and the relation of those results to the leading idea of the 19th century and of our time, the theory of evolution.

That comparative morphology, i.e., the scientific study of form which we find prior to Darwin, had already established the ordering of the plant and animal worlds so firmly that it was absorbed, in its entirety, into the new theory and simply re-interpreted -- testifies that this kind of research had brought to light something of significance. That new interpretation concerning the natural interrelation of form is the interpretation which the systems of botany and zoology were seeking to copy, and it has had far-reaching consequences. For, the same forms found in the original system are found ordered into clear types which, without exception, embrace all variations found among individuals: these types comprise the species, the genus, the family, the order, the class, the phylum. The type is the center of thinking about variation among form-constructs.

However, the picture of gradual form-change within geological time, (the basic idea of the theory of evolution), deeply shakes just this basic idea of clearly distinguished types, and it stresses the flow of unstable transformation. The new mode of thinking preserves the hypothesis that there is a transformation of serially repeated structures, each of which

possesses rich potentials. According to that notion, each of these structures, depending on its place in the total picture of the form, would actualize a different possibility, be it the leaf appendages on the plant shoot, the sequence of individual vertebrae which we see in vertebrates, or -- as in the situation dramatically illustrated in animals possessing limbs -- pairs of limbs following each other on a main axis. We soon find that we must re-emphasize Goethe's pregnant formula, "all is leaf," in our exposition of plant form. In 1868, Casimir de Candolle, the grandson of Goethe's contemporary, Aug. Pyrame, introduced the terms, "partial shoot", for the successive lateral structures along the stem. That new term makes it possible for us to take into consideration the tendency which many blade-shaped leaves exhibit toward a stem-like growth, often magnificently displayed, if not in three dimensions, certainly in the surface plane of the leaf-blade. The new formula is more restrained, but leaves the essentials of Goethe's insight intact.

The last act of the "metamorphosis" of this partial-shoot gives rise to the most vehement discussions. The extent of agreement concerning the correct way to consider the male organs, i.e., the pollen vessels, is precisely balanced by the extent of disagreement concerning the place which the female organs should occupy within the scheme of the partial-shoot theory -- that is, how we should understand the ovary with ovulary, style and stigma, (See Appendix III for diagrams). What is more, this vehement discussion has continued on into the most recent times. Nevertheless, in 1950 our best scholar of the problem, Agnes Arber, reached the conclusion that the partial-shoot theory is rich enough to show that the female organ corresponds to a partial-shoot. This problem, incidentally, leads us deep into the problem of the origin of the flower in the higher plants; up to now, all attempts to deduce the flower from simple stages of organization are inconclusive, and they thus leave an important question unanswered. A review of scientifically based contemporary morphology shows that, on the one hand, while Goethe did not contribute directly to the original formulation and propagation of the theories respecting the metamorphosis of flowering plants, an appreciation of the correlations offered by his theory of metamorphosis will place him high in the ranks of independent researchers and thinkers. This ranking within the framework of specialized research, however, by no means determines the

rank and place of his essay within a perspective gained from a more comprehensive view of nature and the world. Goethe's work on the metamorphosis of plants leads us into a much wider sphere of problems.

Goethe's essay, however much he wished it judged as natural science, represents a far more comprehensive striving for insight into the essence of living forms and, by the same token, into the essence of man and the world as a whole. Many forces whose operations are often sharply conflicting are at work in Goethe's achievement. If we really wish to follow the soaring flights of his mind, we must take all these forces into consideration. And, finally, it is precisely the results of technical research which we cannot use to measure Goethe's effort in the area of morphology if we wish to take his work deeply seriously. If we do take that work seriously, it will also force us to re-examine the temper of our own contemporary natural science.

I can here only recount a few of these results and conflicts. Goethe's early intense interest in the alchemical interpretation of nature was a lasting influence on his own image of nature; the impression was all the more enduring in that it complemented both his deep need for a unified world-view and his powerful imagination. He himself fully recognized the significance of this influence, and very early on he tried to conceal the powerful attraction he felt for alchemy. Even after his intelligence had condemned it, the influence exerted by alchemy persisted: it was within a spiritual world that he tried to grasp whatever is knowable through the full experience of what is given to us through our senses. Thus, colors are the activities and passivities of light. A yet more powerful expression of this alchemical imagination is his essential image of the rising and clarification of the saps in the stems of the flowering plants -- an idea which impelled Goethe to interpret even the formation of pollen in the stamens as a final purification of saps from non-spiritual substances. Goethe, what is more, defended this point-of-view even as late as 1820 -- and thus at a time when the role of pollination in the fertilization process was known.

Bound up with this idea of the refining and purification of matter during its ascent toward the formation of the flower is his belief in the absolute value of the objective experience of form, in the accord of the formally significant with the materially significant -- and accord which

Goethe admired in classical art, particularly after his trip to Italy. It is not by chance that a later admirer of classicism, the art historian Heinrich Woelfflin, declares: "Certain passages of *The Metamorphosis of Plants* have their exact parallels in art history. For, every art historian can accept what Goethe's work says regarding the transformation of the imperfect into the perfect: The parts which originally were coordinate and similar to one another, differentiate themselves and thereby enter into a relationship of superiority and subordination."

His exalted concept of culture as the proper, that is to say, the higher nature of man gives Goethe the certainty that the privileged forms of nature were, at their creation, formed for culture. On contemplating a horse skeleton in a folio of illustrations by Dayton, Goethe thought that he had remarked "that, because of the gentle bending-back of the anterior rod-like spinous processes and the opposite striving of the low flat processes, the beautiful natural saddle and, with it, the horse itself, had been shaped into its perfect form and highest usefulness." For Goethe, even the shaping of the wild form is ennobled by the higher world of human culture. Thus, for instance, when "nature, out of a certain deeply focused, fierce concentration, bends the horns of the primitive bull back on himself, and thereby robs him, as it were, of that weapon of which he would have such need in his natural condition, we saw at the same time that, in his domesticated condition, these exact same horns were allotted an entirely different direction, moving both upward and outwards with great elegance."

We must here take a moment to survey the *modus operandi* of our own contemporary biological research if we want to understand this other approach to nature. This survey will show us more clearly from what point we must consider Goethe's vision if it is to become discernible in its deeper meaning.

I will here turn to the biology of our own time because the contrasts between many aspects of this research have become quite striking in recent decades; for we now realize very clearly the extent to which the living being is viewed as a research object from two extremely opposed perspectives -- a situation which we experience as comprising a powerful polar tension.

Let me here compare the richness, the many sidedness of events within the living being with a magnificent drama being played before us.

If I wish to be completely satisfied in my desire to grasp this drama in its entirety, I must seek out at least two entirely different positions: backstage, that is, behind the proscenium, and also a position out in front, as a spectator. Both positions are important, and both are always necessary. Each position presents different challenges and yields answers to different problems. Now, backstage, I become acquainted with the paraphernalia, the technical procedures, which make a fully adequate production possible -- the workings of thunder and the wind machines, no less than theatrical contrivances which make even ghostly apparitions possible.

Entirely different rules govern out in front of the stage; here we are concerned with relationships between human beings. I must know the language; I must grasp word, sense; and gestures; I must yield myself completely to appearance and, if the performance is to be successful, I must know absolutely nothing of the mechanics which make all that possible: by no means can I know how it is arranged that Hamlet's father appears credible as a ghost.

In the science of our day, the work behind the stage is, far beyond any other consideration, extremely specialized and prodigiously developed. For many it represents true research, *the* goal. And yet, there are many tasks -- let me give as an instance the task of behavioral research, which demands that the biologist be present out in front of the stage as the observer of the theater, whether the play be "The Love Life of the Blue Thrush," The Bumblebee and the Monks-hood," or the plot can even concern the mating play of the stickleback or of a bird, or even a drama of hunter and hunted.

What I experience from in front of the stage is not "more correct" than what the physiologist, the microbiologist, or the molecular biologist learns from behind the stage of life. Starting from either point of departure, the intellect has its work cut out for it; there is a distinct propriety involved in each distinct way of looking at things. Nobody who knows Goethe's work in natural science will be in doubt as to the position he takes as an investigator: indeed, was there ever a more intensely involved spectator out in front of the stage -- giving, as he did, full attention to a colossal play whose language and

gesture, even if they are not immediately intelligible to him, still convince him that they make sense even when all the sense it could make is hidden, and even when the drama itself which plays before the observer is difficult to grasp and is strange to him?

Deeply engrossed, he followed one of these plays again and again and, under the title, *The Metamorphosis of Plants*, he has set down for us, in his own language, what he saw. In this drama of life, the players are simple forms: they are the blossoming annuals, with their clear, open life-course; these are the classical heroes in the play of plant life, the great figures which give us the key to what is less familiar *if* we rightly watch and listen to the presentation. Out of the seed, and hence out of the unity of hidden potentialities, the mysterious separation into the first seed leaves is enacted before our eyes. For Goethe, this is a great simile for the two sexes, and it helps us to recall the original unity both of the androgyne and of the duplex sexual nature of the plant stem which grows upward, out of the darkness and toward the light. Along the axis of this main stem, the sprouting of a profusion of different orders of leaves is regulated by a spiritual law which addresses itself to sense and meaning; we here witness the gradual ascent of these leaf forms which, at the zenith of the vegetative phase, finally reach a form which reveals to us the height of its potentialities, "the climactic form" of today's botany. In this climactic form, we have a realization of secret tendencies, of hidden dispositions which point toward a two-dimensional stem-formation. Such a formation is proper to the disposition of the leaf structures which we find manifested particularly clearly either in palmate, (e.g., the chestnut), or pinnate, (e.g., the walnut), leaves.

The main stem is waiting with new surprises which it springs on us after this vegetative culmination is presented: the climactic leaf is followed by a reduction; for, just after the climactic forms, quite modest forms make their appearance. But, in their very restraint, this succeeding group of forms intimates the secret concentration of the plant on its next great act, the formation of the flower. "Near the earth, the parts are more pressed together; there, they are broader, more watery, more fleshy. It seems that the vessels which contain the water are shaped breadthwise, and that those which contain the oils and the spiritus substances are shaped lengthwise.

Little by little, the interstices between the nodes become longer and thinner....We can," Goethe continues, "persuade ourselves that, because it arises from the preceding node through which it receives the saps -- but only indirectly -- a higher node must therefore receive the saps in a finer and more filtered state; also, that higher node must profit from the influence exerted by the intermediate leaves ...and it must provide finer saps to its own leaves and bud-eyes....The organs of the nodes are refined, and the effect of the unadulterated saps is purer and more potent. The transmutation of the parts consequently becomes possible, and it takes place in the face of all obstacles."

Goethe experienced this process of change with all the potent imagination of an alchemist. Whereas we as onlookers live within the temper and tendency of the plot, Goethe lived among these more hidden lives. No material analysis trespasses on these events; no experiment and no technical intervention disturbs this ordered harmony. The spirit somehow divines what is happening here; the gentle empiricism of analogy guides the spectator as this drama approaches its pinnacle, the miracle of the flower. This empiricism confronts the inquiring observer with difficult questions.

The formation of the calyx, (namely, out of a circle of sepals), clearly reveals a spatially clustered collection of small blade leaves. But the flower? It may well be that the purer saps favor the mutation into the leaves of the corolla, (that is, the next higher circlet of petals). But is not their radiant color perhaps a still further act of purification, of refinement of the saps on their way to their apotheosis in fertilization? For next, those very stem structures which could otherwise form green leaves form two rings: the first comprises the pollen vessels, (which have long been recognized as male elements), and the second comprises the ovary and its ancillary structures which bear the egg cells. What about the petals?

In the 45th section of his *Metamorphosis of Plants*, Goethe remarks that the color and scent of the petals was probably to be ascribed to the presence of the male seed ..., and he reflects that, although the beautiful appearance of the colors certainly presupposes a high degree of purity, it does not as yet presuppose the highest; for, at the highest level, the petals appear to be white and colorless. We here find Goethe already invoking the law of the high rank of white within the context of his interpretation of flower colors -- this twenty years before the final version of the *Farbenlehre*, (*Theory of Colors*)!

That duality which revealed itself during germination by means of the two seed leaves is again manifested in the fashioning of the two sexes. In their turn, the two sexes are destined for a union which leads to the restoration of the original unity of essence which then, there in the seed, sets the stage for a new drama of separation, development and reunion. Goethe explains the high point of this form-transformation from partial shoots into flower, and thus into the visible duality of the sexes, on the basis of a powerful concept. Even as early as 1694, Camerarious in Tuebeingen recognized the sexual organization of the flowering plant; in 1730, the young Linnaeus referred to the magnificence of blossoms as comprising "flower nuptials." In 1760, Koelreuter in Karlsruhe shed yet further light on the subject, and sometime around 1787 -- during the time of Goethe's trip to Italy -- Konrad Christian Sprengel of Spandau began his observations on the collaboration of insects in the act of insemination. No one at that time yet knew about the cellular activity taking place in these structures; it was not until 1815 -- but not really clearly until 1842 -- that this new phase began. During that period, when Goethe was expounding the *Metamorphosis of Plants*, he had to enlist the old theories of saps in the interpretation of this still obscure process. Thus, even the aging Goethe welcomed the views of the Jena botanist, Franz Jos. Schelver, who had carefully scrutinized the theory of the sexuality of the plant as early as 1812 and had built on Goethe's views. This Shelver "was, under protest, refused entry into the courtyard of the temple of science," Goethe reports ironically in 1820; "But," he continues, "a seed, no matter where it is cast out of, takes root just as soon." In about 1820, we find Aug. Wilh. Henschel of Breslau again championing Schelver's view and thereby supporting Goethe's interpretation:

> "Schelver carefully traced the peaceful course of metamorphosis, which advances in so noble a fashion that everything material, lesser, or meaner is little by little left behind and the higher, the spiritual, and the better is allowed to emerge in greater freedom. Does it not then follow that this latter pollination might encompass nothing but a liberation from burdensome matter, and then, might it not be that the fullness of what is most truly inward at last emerges clearly from a living, primary, force into an endless process of reproduction?"

Goethe saw a salvation and a purification of the theory of the sexuality of plants in Schelver's theory. "One could allow the claims of wind and insects and be richly paid back by metamorphosis," Goethe writes in answer to K. Chr. Sprengel. "These endlessly performed wedding ceremoniies," he wrote in 1820 in answer to Linnaeus, "from which we will never be entirely free, entirely dissolve that monogamy upon which morals, law and religion are founded, and entirely dissipates it into a vague concupiscence which continues to be completely intolerable to the purely human sense of things."

And thus, when he contemplated the blossoming plants, Goethe adhered to the idea that the formation of pollen is the last purification of the saps along the axis of higher development. He interpreted the uniting of the sexes as a secret anastomosis of conjugation at the pinnacle of the plant axis -- and, in his yearning toward a highest perfection, he asked himself whether there might not exist somewhere the true monandria-monogynia, the union of a masculine with a feminine element, instead of this vulgar harem of masculine partners around an isolated feminine center. The secret anastomosis also signifies the highest concentration in space, the closest possible approach to the transforming elevation of space and time, an event involving the spirit and even an allegory of the unification of God and man. This is the great instant, the instant Goethe yearned for and sought to shape after his experience of Italy. Flower formation and fertilization are the zenith of plant life. Here, past and future are united, gathered together in one great moment. The notion of the zenith of a life is essential for Goethe's concept of the organism. Thus, for him, "puberty...for both sexes is the instant at which the form is capable of the highest beauty; but, one may well say: It is only an instant! Procreation ...costs the butterfly his life, man his beauty!" And in another place, he notes that, "the fruit can never be beautiful...." Thus write the 75 year old Goethe -- true to his conviction concerning the zenith of life.

In our world, according to Goethe, the life drama of the primitive plant is enacted in its most beautiful approximation by the blossoming annuals with their two paired seed leaves -- by the dicotyledonous angiospermae. Here is expansion, development, and constriction; what had been

united is here separating toward richer reality; the separated united toward pregnant new unity; the repetition of the eternal diastole and systole. Here is the great reality involving both the polarity and intensification of formation, so that "everything material, lesser, or meaner is gradually left behind, and the higher, spiritual and better is allowed to emerge in greater freedom."

In his reflections, Goethe attended a great wordless play; such an observer brings into play an extreme objectivity which, at the same time, preserves the full richness of his symbol-world, his inwardness. In this great spectator, sentience and mental power celebrate their highest reconciliation. The plant world is a "manifestation of our God, and not simply a sing of His glory", as he wrote Herder on his birthday of 1787 when he was only 38 years old, and he experiencing the powerful impression of the vegetation of the Italian South.

The presentation of plant metamorphosis which I have just attempted to give in Goethe's very words is not a review of a great work of the past: it leads into problems which are of quite immediate concern to us at present. Must we not see -- to continue our analogy of the drama -- that the investigation of living creation from out in front of the stage remains the necessary complement of the work which presently takes place predominantly behind the scenes? It is no accident that, at a time when the impulse toward molecular research, microbiology, and biochemistry has been heightened to the highest degree, the necessity for biology to fathom the utterly different world belonging to the psyche, to the world of form and its behavior, has likewise been intensified to the same degree. Even that environmental research which is so pressing today requires that, in wide areas, we take a more profound view of the phenomena in front of that stage -- however hard at work that research behind the stage might be, working as it is in the service of a knowledge which aims at domination, as Max Scheler might once have put it. Within the scientific thinking of our time there are two currents of thought which help to make us aware of the much-neglected experience of the playgoer viewing the stage from out in front. One current is comprised of morphology and behavioral research, sciences working within the field of our experience of sensible objects in polar tension with their excursions into the invisibility of matter; the other current is comprised of

environmental research as a defense against a lethal menace of our own making. But we must say more. The exploration of the drama of nature from the spectator's point of view in front of the stage results in the appearance on that stage of mysterious celebrities who guide our thinking inexorably beyond just those boundaries at which the strict methods of natural research must call a halt. Because of the intentionally self-limiting character of science, life is always more than it can state. Likewise, our experience of the forms of nature around us is more than we can rightly utter with scientific certainty. Therefore, the creative imagination will always persevere in its attempt to locate the partial results of genuine research within a very much more exalted whole.

It is thus, that, in his mighty drive to synthesis, Goethe boldly overstepped the boundaries within which science consciously restricts itself. He saw his experiences of living creation as a great spectacle constructed on a widely extended recognition of the great basic forms of experience which include, for instance, harmony, polarity, and intensification. But that very experience must, he realized, also build on interpretations which resonate with those of earlier times, interpretations such as lie at the basis of the images of the great chain relating all being or the age-old symbolism of alchemy.[2]

Those who follow after us will construct their own new interpretations upon their own new insights; if they are of an open mind, Goethe's work will provide them with a model of spiritual ascent toward just that comprehensive relationship within nature which strict science cannot provide. Through its boldness of perception and conception, Goethe's vision of plant metamorphosis has placed the greatness of living being before our eyes.

We are now living at a time when we can re-experience what is exemplary in an essay such as Goethe has given us in his *Metamorphosis of Plants*; for, we now live in an age which has become optical to an unheard-of extent, at a time in which the language of the eyes favors a virtually new analphabetic form for what is alive. The accelerated development of biological research using biotechnology probes the realm of the invisible in order to attain domination over natural processes. This development is unavoidable, and it will certainly bring with it a terrifying erosion of our

relationship to living forms if we do not at once begin to reflect on the benefits which accrue to every aspect of human culture from a rich commerce with those forms. We must face the necessity for new modes of natural science and, in particular, for a natural science which is not a weak shadow of a science, but, to the contrary, which leads to a deepened commerce with the world of living forms and makes nature into our true home. Reverence for the revealed mystery of life: that is the great demand made upon such a new natural science. May my essay on the *Metamorphosis of Plants* serve to help us recollect that we must undertake this task.

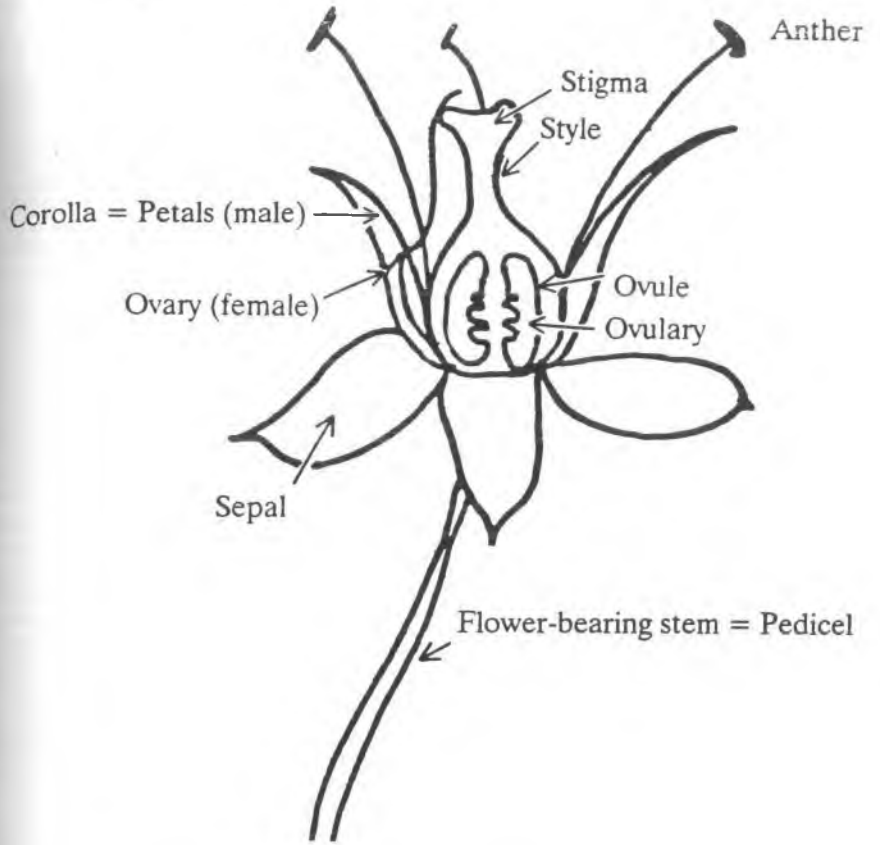
CHAPTER VIII
Endnotes

1 "*Goethe und der Begriff der Metamorphose*," *Goethe Jahrbuch*, Helmut Holtzhauer, ed., 90 Band der Gesamptfolge, 1973; Verlag Hermann Böhlaus Nachfolger, Weimar, pp. 11-21.

2 (For a sober and well-researched work on Alchemy and its influence *via* Newton on the tradition, see: Eliade, Mircea, *The Forge and the Crucible: The Origins and Structures of Alchemy*, Trans. from the French by Stephen Corrin, (Chicago and London: The University of Chicago Press, 1962, 1978). This was originally published as : *Forgerons et Alchimistes*, Paris: Flammarion, 1956). (Trans.)

APPENDIX III

Flower



1. Ovary: female seed-producing organ;
2. Ovulary: expanded hollow base of style contains unripe eggs or ovules;
3. Stigma + Style + Ovule = Pistil--female sex organ.

APPENDIX IV

GOETHE'S BOTANY

Versuch Die Metamorphose Der Pflanzen Zu Erklären
(*An Attempt To Interpret The Metamorphosis of Plants*, 1790)

with an introduction & translation
by
Agnes Arber, D.Sc., F.R.S.

Author of: *Herbals, Water Plants: A Study of Aquatic Angiosperms*, *Monocotyledons: A Morphological Study*, and *The Gramineae: A Study of Cereal, Bamboo, and Grass*, etc.

INTRODUCTION[1]

The botanist who attempts to study Goethe's scientific work, finds himself dealing merely with one facet of a mental life unexampled by its many-sidedness. This one facet is so completely integrated with Goethe's general productivity, that it cannot be understood except in connection with the whole; but to see it thus in perspective demands an acquaintance not only with his own vast output of writings, letters, and recorded speech, but also with the immense corpus of Goethe scholarship. This can scarcely be compassed by any man of science outside Germany.[2] Another difficulty with which the student of Goethe's botany is faced at the outset is that those scholars who have the fullest and most critical knowledge of his writings, differ radically in their estimate of his science, both in its relation to his work in general, and when considered in itself. At one extreme we have authorities, such as J. G. Robertson, who speaks with regret of the large share that science took in Goethe's activities, and who voices the doubt whether his scientific interests, "were not as real a crime against the majesty of his poetic genius as his immersion in the routine of state government"[3]; and Sir Charles Sherrington, who remarked in a recent lecture: "Were it not for Goethe's poetry, surely it is true to say we should not trouble with his science."[4]

At the other end of the scale stands W. Troll, who maintains, in a fully reasoned study of Goethe's morphology, that the centre and focal point of his whole mental life is to be sought in his scientific writings.[5] We meet with the same conflict of opinions when the value of Goethe's scientific work is assessed in itself, rather than in relation to his general output. Sherrington, for instance, dismisses the metamorphosis idea as "no part of botany today", and adds that "Goethe's view has gone the way of unsupported theories";[6] on the other hand, Troll - a botanist -- ascribes to him the credit of having actually founded the science of morphology,the name of which he invented.[7]

Goethe himself was very far from considering his work in natural science as a mere side issue of his career as a poet. In old age, when reviewing his past, he declared that a great part of his life had been devoted to science, not only with inclination and with passion, but also with consistent effort; and he definitely claimed to be estimated seriously as a scientific worker.[8] Whether, with Robertson, we should regard Goethe's science as a grievous lapse, or, with Troll, as one of the fertilizing sources of his creative life, or whether a somewhat different type of appraisement is needed, will become apparent after we have reviewed the botanical aspect of his work, and the tendencies of his thought in biological matters.

Goethe's childhood and youth were passed in towns, and it was not until he went to Weimar that vegetation came prominently under his eye; for there he found himself in the midst of fields and gardens, while hunting -- a favorite pastime of the court -- led him into the Thuringian forests. His responsible concern for everything local made him interest himself in the technique of forestry, which had been brought to a high pitch in the duchy. Moreover, owing to the Duke's amicable relations with his neighbors, even those forests which lay outside his boundaries were freely open to Goethe. In this woodland country, which he came to know intimately, he made acquaintance with the herbalists to whom the apothecaries in the towns owed their supplies. These herbalists made all kinds of medicinal extracts, handing on their secret recipes from father to son. It was under their auspices that he learned to know, in particular, the different kinds of gentian, which were valued for the curative properties of the root; this was the first genus in which he studies specific distinctions. In retrospect Goethe took pleasure in the analogy between his personal botanical history, and the history of botany in general, and it was only gradually that he came to be attracted by the subject in its theoretical aspect. Goethe's botanical tastes were stimulated especially by contact with a remarkable family -- the Dietrichs of Ziegenhain[9] -- amongst whom, through a series of generations, a passion for botany asserted itself again and again. In 1688 a certain Salomo Dietrich, an exile from Bohemia for religion's sake, had fled to Thuringia, where he took a farm. In 1711 a son Adam was born to him. Adam succeeded his father in the farm, and one of his undertakings was to send weekly supplies of plants, for

botanical purposes, to the University of Jena. He became well known as the Ziegenhain "Botanicus"; he treasured a letter written to him by Linneaus with his own hand -- a document which he honored as a patent of botanical nobility. Love of plant study extended to the fourth generation from Adam Dietrich; his great-grand-son, A. W. S. Dietrich, made and sold herbaria, and trained his wife, a village girl of Saxony, in all the necessary technique. Though not a Dietrich by birth, she proved to have a supreme flair for field work, and she is remembered for the adventurous and solitary years she spent in North Australia, collecting for Godeffroy; she lived into the last decade of the nineteenth century. The member of the family, who was specially associated with Goethe, was Amalie's uncle by marriage, F. Gottlieb Dietrich, born in 1768. Goethe met him in the seventeen-eighties, and was so much pleased with his knowledge of Linnean botany, and his ecstatic happiness in it, that he took him as a companion when he went to Carlsbad for a cure. On the journey, Gottlieb searched for plants, bringing them to Goethe's travelling carriage, while proclaiming their Latin names like a herald. When Goethe had settled at the spa, Gottlieb was away among the mountains by sunrise, hunting for flowers, and was able to bring the spoils to Goethe before he had finished his morning draught of the waters.

For a time, Goethe remained wholly devoted to the Linnean system, giving himself up to it with absolute confidence. As books which he was constantly studying, he names Linneaus' *Fundamenta botanica*, *Termini botanici*, and *Elementa botanica*, and also Johnann Gessner's *Dissertationes*. The latter work, which explained the principles of Linneaus, was published under his aegis.[10] Even when Goethe had lived through the first ardour of enthusiasm for studies of this type, and had published refutations of certain erroneous views held by Linneaus,[11] he still retained a reverence for the master himself, but the nature of this reverence has sometimes been misunderstood by Goethe students, and its degree exaggerated, on the strength of a sentence in a letter to Zelter, written on November 7, 1816.[12] He says, speaking of Linneaus, "Except Shakespeare and Spinoza, I am not aware that any man of the past has had such an influence upon me." This is, at first sight, a startling remark, for it is impossible to believe that a man of Goethe's mental calibre could have ranked Linneaus actually with either

Shakespeare or Spinoza. A careful reading of this and preceding letters sets the matter, however, in a different light; for it becomes clear that Goethe's words do not relate to these three men, appraised in themselves, but merely in their effect upon his own personal development, an effect depending largely on his individual circumstances. It is important to notice that, in the letter just cited, he avows that, though he has learned an infinite amount from Linneaus, what he has learned has not been botany. In the previous month[13] he had told Zelter that a return to the study of Linneaus, many years after he first came to know his work, had brought him to recognize that he has used the Swedish master in symbolic fashion only; that is to say, he has sought to transfer Linneaus' method and mode of treatment to other subjects, thus gaining an efficient mental instrument. We have to remember that Goethe had undergone no explicit training in scientific discipline, and that he apparently knew little about pre-Linnean plant study. His tendency was to regard the whole corpus of systematically-developed biological thought as being the outcome of the genius of Linneaus alone. This attitude, which was very common in those days, was condemned by Batsch, a botanist which whom Goethe was acquainted.[14] Batsch greatly admired Linneaus, but, in a book published in 1787, he protested against the injustice of exalting him at the expense of the many other writers who, in the eighteenth century, had promoted the knowledge of plants.[15] We can completely understand Goethe's share in this overestimate, when we consider his intellectual history. When he first read Linneaus' writings, they supplied what was his crying need at that stage -- an objective and scientifically methodical approach to botany; none of his previous studies in literature, law, or art, had been able to do him this particular service.

Despite the fervour with which, in his earlier pursuit of plant science, he had followed Linneaus, nothing could make detailed systematic botany really native to Goethe. Although, stimulated by Gottlieb Dietrich, he learned something of the application of the Linnean system in the field, he came gradually to the conclusion that the minute analysis and counting of the floral parts, which it involved, were not in his line: "Trennen und Zahlen lag nicht in meiner Natur." At that date, when optical aids were not as advanced as they are today, a disinclination for the study of small objects must often

have arisen simply out of visual difficulties; but, in Goethe's case, the reaction against such occupations seems to have been primarily a deep-seated mental one. He himself contrasts the way of studying nature which consists in proceeding analytically into the individual particulars, with that which consists in following the clue holistically through breadth and height;[16] it was to the latter method that his limitations as well as his powers inclined him. He realized that the devotion of a lifetime, and aptitudes of a special order, were necessary for comprehensive and intensive systematic work, and held that for him there was another way, more in keeping with the rest of his course through life, namely the contemplative study of the phenomena of change and mutation in the organic world -- phenomena which had created a deep impression upon his mind.[17] In process of time the systematic aspect of botany seems, indeed, to have lost its appeal for him altogether. Late in life he wrote that nature has no system, but that "she is the transition from an unknown centre to a limit which is not discernible", and that "Natural System" is thus a contradiction in terms.[18] Even in the earlier period, when Goethe's ideas about biology were in their plastic phase, he was not alone in feeling a certain dissatisfaction with the way in which systematics, in the Linnean sense, had come to dominate botany. Hedwig, a writer with whose work Goethe was acquainted, pointed out in 1781 that plant study had been too much concerned with the examination of new material from all parts of the world, and with detailed descriptive work, to give much consideration to the "inner economy" of the plant on which all depends.[19] It was this "inner economy," and the morphological signs through which it expresses itself externally, on which Goethe's interest was finally concentrated. He could not however have thrown light upon this aspect of the subject but for his earlier apprenticeship in looking closely at plants for the purpose of detecting their taxomonic marks. His practice in handling them impressed him with the contrast between the inevitable rigidity of the classificatory system, and the versatility of the organs themselves. Certain plants, for instance, came to his notice in which the same stem bore a crescendo series of leaves, of which the earliest were entire, and the next lobed, while an ultimate, almost compound-pinnate shape was succeeded by a diminuendo series of simplified forms, gradually reducing to small scales, and thence to nothing. The systematic

botany of the period paid little attention to the plasticity of leaf structures, and Goethe was unable at first to find any clue to the part which these transformations played in the general scheme of things. It was his journey into Italy, with the sight which it yielded him of a flora, both wild and cultivated, which was rich to a degree undreamed of in his more northerly home, and to which his mind was not deadened by familiarity, that finally set in motion a train of ideas which was to dominate his conception of the plant world for the rest of his life. A glimpse of the southern vegetation which so delighted him is revealed in his sketch of fig tree and maize.

One of his crucial experiences was his visit to the botanical garden at Padua. Here he saw a palm, Charmaerops humilis L., from which he collected a series of leaves, ranging from early lanceolate forms, up to the mature fan, and then, by a sudden transition, to the spathe enclosing the inflorescence. These leaves he carefully preserved, and, thirty years later, he confessed to still regarding them as fetishes, because of the way in which they had arrested his attention at a critical juncture. The botanical garden at Padua has the longest history of any in Europe, having been founded in 1542, and Goethe's palm, which still flourishes,[20] is said to date from as long ago as 1584. Though his suite of palm leaves set Goethe pondering, it did not give him immediate illumination; this came after, in April 1786, he reached Sicily -- the ultimate goal of his travels -- and during his return journey to Rome.[21] The conviction of the original identity (ursprungliche Identität) of all the members of the plant then became explicit in his mind. The *Versuch die Metamorphose der Pflanzen zu erklaren*,[22] published in 1790 -- the year in which Goethe was forty-one -- is the reasoned outcome of the meditations which began to take shape beside the palm tree at Padua. Goethe realized, in the first place, the identity of the various forms of foliage leaf and bract, and then extended this conception to the parts of the flower. It was by no means the first time that ideas of this kind had occurred to botanists; to equate at least the outer members of the flower with leaves, has, indeed, always been natural to any acute observer. In the fourth century before Christ, Theophrastus had used the word "leaf" (*to phullon*) for the corolla.[23] Some 2000 years later, Nehemiah Grew[24] gave excellent anatomical reasons for considering sepals and petals as equivalent to foliage leaves, and -- as

regards to sepals -- he called in also the evidence of abnormal forms. Grew's contemporary, Marcello Malpighi, again, described and figured the intermediates which may occur between petals and stamens in the rose.[25] These seventeenth-century anticipations were somewhat fragmentary, but, in 1768, more than twenty years before the publication of the *Metamorphose*, C. F. Wolff[26] made a remarkably complete though brief statement of views closely related to those which Goethe afterwards developed. Wolff wrote that in some plants it is obvious that the calyx is a collection of relatively small and imperfect leaves, and that the pericarp is no less evidently composed of true leaves, which are, however, united. Petals and stamens, also, are *folio modificata*. Transitions between sepals and petals can be observed, and, in flowers with numerous stamens, these often degenerate into petals.[27] Goethe was unacquainted with Wolff's work when he wrote the *Metamorphose*; at that time, indeed, his knowledge of the relevant botanical literature was far from complete. He had no conception of the modern code according to which the scientist is under an obligation to read all that has been published on any problem before putting forward a solution of it as being his own. On the contrary, Goethe undoubtedly felt himself entitled to full credit for any notions, which he had himself evolved without conscious borrowing, even if others happened to have expressed them before. He maintained[28] that the savant should use his predecessors' work without indicating his sources at every turn, although he ought to express his gratitude to those benefactors who have unlocked the world for him. Despite Goethe's keen desire to be regarded by professional workers as a fellow scientist, the technique of his approach remained essentially that of the literary man, who is not expected to give a detailed enumeration of his sources in, for instance, a poem or play. The *Metamorphose* must be judged, not as if it were a modern scientific treatise, but as a presentation of a nexus of ideas, much of the material for which was already in existence. These ideas Goethe alone succeeded in developing into a unified organic whole, by adjusting them to the living framework of his thought, and thus creating one of the minor classics of botany.[29] It has been claimed that, on his Italian journey, his passion for the scientific study of nature closed with and worsted his creative instinct;[30] but such a view cannot be accepted by those who hold

that creative insight can find its play in morphology as well as in poetry. It is this very quality which has given Goethe's botanical work its permanent life.

Goethe met with some difficulty in connection with the appearance of the *Metamorphose* in book form.[31] His regular publisher, Goeschen, declined it, but Ettinger of Gotha produced it in 1790; as Goethe himself notes with satisfaction, it was beautifully printed in Roman type. The title-page is shown in facsimile on p. 88. A reprint, not identical in format, was issued by Ettinger in the same year.[32] On casually turning over the pages of the *Metamorphose*, one may get a somewhat staccato impression, since it consists of a series of 123 short numbered paragraphs, which in the first edition were spaced rather far apart; these paragraphs are grouped into eighteen parts. The sense, however, tends to run on without a break even from part to part. Extreme examples are the transition from the end of Part III to the beginning of Part IV, which opens, "This (dieses) seems still more probably" -- "This" being inexplicable without reference to Part III; or the transition from the end of Part X to the opening of Part XI, which begins, "On the contrary," (Dagegen), thus carrying on the argument continuously from the preceding part. Paragraph 92, also, may not be understood unless it is recognized that it is abstract of the conclusions of Gaertner, to which reference has been made in the previous paragraph. The word *Metamorphose*, in the title of Goethe's book, was not altogether a happy one for this purpose. From classical times it had had poetical associations, which might well lead the reader to expect a work of fancy rather than of science, especially when the author was already famous for his imaginative writing. Goethe himself complains that, on telling one of his friends that he had published a little volume upon the metamorphosis of plants, the friend expressed his delight in the prospect of enjoying Goethe's charming description in the Ovidian manner of narcissus, hyacinth and daphne.[33] There was also a certain confusion inseparable from the term metamorphosis, because it had been not only used in describing the life history of insects, but had, in addition, been taken over by Linnaeus into botany, in a sense different from that of Goethe; Linnaeus employs it in connection with the change from the vegetative to the flowering phase, which

he seems to have regarded as analogous to the change from the caterpillar stage to that of the perfect insect.[34]

Apart from these questions of accepted usage, the term metamorphosis was not in itself exactly applicable to the events with which Goethe dealt. As Jaeger[35] pointed out in 1814, the expression cannot be more than symbolic, since we do not, as a rule, witness an actual process of transformation; to say that any organ, as we know it, has been "transformed," is thus merely a figure of speech. The term metamorphosis can only denote a change which we imagine happens in the formative force (Bildungskräfte), rather than anything detectable in the visible members, though it is from the observed differences in the visible members that we deduce the existence of this underlying metamorphosis. Jaeger's criticism is fully justified, and it is useful as stressing the elusiveness of the ideas in which Goethe dealt, and the fact that even he himself did not always succeed in grasping them firmly.

The development of Goethe's theory in his little book is on the whole so limpid in expression that commentary is seldom needed to make it fully intelligible today. The thread, upon which the whole exposition is strung, is the idea of metamorphosis in its two main aspects: *normal* or *progressive*; and *abnormal* or *retrograde*. Normal metamorphosis is the change seen in the successive types of lateral appendage, from the cotyledons, through the foliage leaves, and bracts, to the final reproductive goal in the fruit. In abnormal metamorphosis, on the other hand, there is, in the ascent towards reproduction, a back-sliding to a level which has already been passed, as, for example, when a stamen is developed in petaloid form. It should be noticed that Goethe uses the term "leaf" (Blatt) for the member which undergoes successive changes, appearing in the guise of one lateral appendage after another.[36] Goethe himself recognized that this terminology is unsatisfactory, since the word "leaf" is inseparably associated in daily usage with the foliage leaf, whereas, in his view, the foliage leaf has no more claim to be itself the typical "leaf" than has, for instance, the cotyledon or the stamen. A generalized term, such as "phyllome," which was given currency in the nineteenth century especially by Naegeli-,[37] meets the case better than "leaf", since it is not hampered by special associations. Goethe's recognition that neither the foliage leaf, nor any other appendage, is in itself the "type" leaf, is

perhaps the most original feature of his theory. It represents an advance beyond the position adopted by Wolff, who seems to have regarded the other appendages simply as modifications of the foliage leaf. This difference may be associated with a general difference between the outlooks of the two men; Wolff was primarily a scientific observer, and Goethe, primarily an intuitive thinker.[38]

Goethe was not satisfied merely to note the outward signs of metamorphosis; he wanted also to understand its mechanism. The theory at which he arrived was that the changes in the passage from cotyledons to reproductive appendages are due to the gradual elaboration and refinement of the sap as it travels from node to node. At Goethe's date there were no means of developing such a theory in detail, but the view he tried to express may well be regarded as foreshadowing modern ideas upon the relation of chemistry and form.[39] It has also been suggested that the process of metamorphosis, as visualized by Goethe, may be restated in twentieth-century terms by interpreting it on genic lines.[40]

A notion upon which Goethe laid much stress in the *Metamorphose* was that the annual plant shows six alternating stages of expansion and contraction. He considered that expansion took place in the passage from the cotyledons to the foliage leaves; the calyx to the corolla; and the sexual organs to the fruit. Contraction, on the other hand, occurred in the passage from the foliage leaves to the calyx; the corolla to the sexual organs; and the fruit to the seed.[41] The artificiality of this scheme is obvious, but Goethe may have been dimly groping after a conception of periodic rhythm in the development of appendages at the growing apex.

Another hypothesis which Goethe used in his interpretation of plant life, but which is out of accord with modern views, is that -- derived from Hedwig[42] -- of the prime importance of the spiral vessels or tracheids (Spiralgefässe).[43] It is not surprising that almost magical qualities should have been ascribed to these elements in the early days of anatomy, for the crudest technique revealed them distinctly, and it was natural that their spring-like form should suggest peculiar powers. We cannot reproach the earlier writers with their over-emphasis on spiral vessels, when we recall the way in which, even today, the conspicuousness of xylem in stained sections

leads botanists at times to treat it as if it were something with an independent identity of its own, merely embedded in the rest of the tissues, like the waterpipes in a building. Goethe was so much intrigued by the ideas aroused by the spiral tracheids, that, after the *Metamorphose*, he carried his speculations on spiralness in general to a further point in an essay *Ueber die Spiral-Tendenz der Vegetation*.[44]

The small amount of controversial matter to be found in the *Metamorphose* includes a disclaimer of the fanciful theory put forward by Linnaeus under the name of *Prolepsis*[45] or Anticipation. Linnaeus supposed that vegetative buds consisted of a succession of buds within buds, going on to the sixth generation; no doubt this was an offshoot from the doctrine of preformation,[46] which had so widespread an influence in the eighteenth century. He accounted ingeniously for the occurrence of the reproductive phase by postulating that, when a bud produced a flower instead of a vegetative shoot, the six generations enfolded in the bud all came to light at once -- future years being as it were, anticipated, and the leaves of successive years being transformed in their due order into bracts, calyx, corolla, stamens, and the pistil with its seeds. Linnaeus also believed that he had hit upon the mechanism by which the plant achieves this metamorphosis; he supposed that the leafy shoot becomes changed into the flower by the conversion of the cortex into the calyx; the liber into the corolla; the wood into the stamens; and the pith into the pistil with its contents. Goethe rightly demonstrated the futility of this attempt to relate floral parts to successive zones of tissue.[47]

The theory embodied in the *Metamorphose* has had to face much opposition, part of which has been due to careless and often second-hand misinterpretation, but, apart from this, which can easily be remedied, a residue of genuine difficulty is left, due to certain inadequacies in the theory as Goethe conceived it. The artistic economy of his exposition was achieved at the expense of deliberate and ruthless exclusions, which to some extent reduce the significance of the work. He limited his consideration, for instance, to the annual herb,[48] paying very little attention to other life forms, and he specifically omitted monocotyledons in discussing seed-leaves.[49] Within the plant itself, his interest scarcely extended beyond the lateral

appendages of the stem, and the root he practically ignored. It is true that, in some notes not included in the *Metamorphose*, he spoke of the root as a leaf that absorbs moisture under the earth.[50] He did not, however, follow out this suggestion, and later in life he went so far as to ask how he could be expected to concern himself with such an organ as the root, which shows no ascending progress (Steigerung).[51] Indeed, as Turpin[52] pointed out long ago, Goethe's treatise cannot be said to deal, as he claimed, with the metamorphosis of *plants*, since it is only the metamorphosis of the *appendicular organs* of the stem which comes within its purview. Such limitations of the scope of the work would have been entirely harmless if Goethe had recognized that the problem, as he set it to himself, and consequently the solution which he proposed, were in their very nature incomplete, and represented, not a full morphological interpretation, but merely a single step towards such an interpretation. He did not, however, see the matter in this light, but he treated his theory, of which he was enamoured, as having the finality of a work of art, rather than the provisional character of a work of science. Though he lived for more than forty years after propounding his thesis, and remained deeply interested in it throughout that time, he was inclined to treat it as something achieved once and for all, rather than as a stepping-stone to further developments. He was prepared to amplify it, and offer additional evidence for it, but he did not feel the urge to leave it behind, as an outgrown phase in a continued progress. It was a defect of Goethe's amateur pursuit of science that he was too much attached to his personal notions and never attained the professional's hard-earned capacity for seeing his own work in due proportion in the general stream of thought. He himself defended the amateur standpoint, on the ground that the non-professional, being free from the obligation to strive after completeness of knowledge, is better able to reach a height from which he may gain a broad view.[53] He failed, however, to realize that detailed knowledge, not limited to the worker's own special line, though it may seem of little value considered in itself, is yet essential as forming a framework of reference for general principles. He would not have sympathized with the artist who said that the best way to get a broad and generalized effect is, not to ignore the detail, but

to paint it in, and afterwards to scrape it out remorselessly with the palette knife.

The confinement of Goethe's interest to the lateral appendages of the stem was one of the effects of his amateur outlook. This limitation led him to consider the leaf as a primary member. He treated it as "given," and therefore never attempted to ask the question, "What is the leaf?" This question would have seemed to him to fall outside the sphere of legitimate enquiry. It was characteristic of his approach to problems of thought that he drew a definite distinction between those problems which were suitable for investigation, and others which should be quietly reverenced and left untouched.[54] If he had felt himself justified in trying to understand the nature of the leaf, he might have come to visualize this member, not merely in itself, but also in its relation to the plant as a whole; and he might then have realized that the shoot is a more fundamental unit of plant construction than the leaf, and that the leaf should be explained in terms not of itself but of the shoot. As it was, the leaf was not clearly seen in relation to the shoot until much later, when Casimir de Candolle,[55] in the latter half of the nineteenth century, suggested that the leaf might be regarded as *a partial-shoot*. He supposed that the limited growth, and the dorsiventrality, of the leaf as compared with the shoot, might be interpreted as due to the atrophy of the apex and ventral face of the terminal meristematic cone. More recently, as a development of this view, the idea has been propounded that the leaf is *a partial-shoot, which shows an urge towards whole-shoot characters.*[56] It should be understood, however, that this modern version of the partial-shoot theory of the leaf, even if it be an advance on Goethe's view, makes no claim to be a final morphological interpretation of the plant body. As a further step, an attempt has been made towards a parallel explanation for the root.[57] This attempt is, admittedly, most tentative, and no doubt some generalization of a more inclusive character will eventually grow out of this sequence of opinions, absorbing and transcending them. Unfortunately, in the long period that has elapsed since de Candolle's theory was set forth, little notice has been taken of it by botanists, while, on the other hand, Goethe's treatment of the leaf as an irreducible unit has remained permanently influential; this is partly, perhaps, because the

suggestion that anything may be accepted as "given," and therefore not to be questioned, often receives a ready welcome as a trouble-saving device. Even today, modern German morphology, of the school that sees all hope for the future in a return to Goethe, takes a postulate that the leaf is a "Grundform", in no way derivable from any other member of the plant body.[58] This is indeed scarcely fair to Goethe, since he himself had moments when -- though sometimes in an inverted fashion -- he made an approach towards the partial-shoot theory of the leaf. In one of his notes, after saying that "Alles ist Blatt," he suggests that the stem is a leaf that becomes radially symmetrical (Ein Blatt, das sich gleich ausdehnt).[59] Again, he writes of compound leaves as "in reality branches, the buds of which cannot develop, since the common stalk is too frail."[60]

At the time when Goethe published the *Metamorphose*, he intended eventually to produce, as a sequel, a more comprehensive account of the subject, fully illustrated. His commitments -- literary, scientific, and administrative -- increased, however, so rapidly, that the scheme was never fulfilled. It is at least arguable that this failure is not to be regretted. In its own small-scale *genre*, the *Metamorphose* is a finished work, and it is doubtful if any attempt to expand it, without a definite strengthening of the thread theory that runs through it, would have been happy in its result; the book in its 1790 form was, in Geoffroy Saint-Hilaire's phrase, "immédiatement complète."[61] Though the larger work projected was never written, Goethe continued all his life to amass material bearing on his theory of plant morphology. As well as the writings printed in his lifetime, all his extant notes on the subject have been retrieved and published with pious care,[62] including even the scribbles with the aid of which he jotted down his ideas on plant form; an example of these "characteristischen Federstrichen" is reproduced on p. 118. Fragmentary as his notes are, they are still rich in suggestion for thinkers of the present day. Judging him by the *Metamorphose* alone, modern botanists have been liable to underestimate Goethe's actual botanical knowledge. We have now learned, however, that he was not only active as a collector, but that the pictures which he got together with a view illustrating his definitive work, bear witness to acute observation and a keen, if selective, insight. These drawings were made under his direction, and, in

part, with his own hand. He had a number of them engraved, so that they would be ready when he required them; but one of the hindrances to the production of his intended book was that, when the copper-plates were wanted, they had been mislaid, and they do not seem to have been found during his lifetime.[63] In the present century many of Goethe's figures have been brought to light and printed. One set of pictures is from a small portfolio dating from 1795,[64] preserved in the Goethe-Nationalmuseum at Weimar; it was published by Hansen in 1907.[65] Another set, including drawings from a large portfolio of 1830 in the Weimar Bibliothek, has been exquisitely reproduced by Schuster,[66] with a full critical commentary, and some reconsideration of Hansen's material. This corpus of botanical drawings, in which teratology is strongly represented, and which also includes beautiful studies of seedlings, shows that Goethe was fully alive to those aspects of factual detail which bore upon subjects which interested him. One illustration, which is of special significance in connection with Goethe's morphology, shows the various forms of compound leaf met with in *Aegopodium podagraria* L. (goutweed).[67] These colored drawings were made by a professional artist on the basis of pencilled outlines, which Schuster believes were Goethe's own. Goethe's attention is known to have been specially attracted by the foliage of this plant, for one of his notes[68] mentions its "remarkable *folia composita*," of which "the single leaflets are in part composite again, in part more or less indented, or completely simple"; and Goethe records his intention of making a collection of them. His strong and wide-ranging artistic gift, shown, for instance, in the drawings on pp. 65, 116 and plate 25, was invaluable to him as a botanist. His preliminary sketch of an opening horse chestnut bud with its "calyx" of bracts is reproduced on p. 116. Another picture, which is of peculiar interest to students of Goethe's botany, is that of a proliferating pink.[69] This delicate pencil outline is apparently by Goethe himself, for in the summer of 1787 he found such a specimen in Italy, and mentioned that, since he had no means of preserving this marvellous form (Wundergestalt), he attempted an exact portrayal of it.[70] It was evidently a labor of love, for he wrote of the plant in question as embodying all his ideas, and giving him rapturous delight.[71]

This rapturous delight seems to have been aroused in Goethe's mind primarily by any fulfillment of his desire to resolve the antithesis between the many and the one -- a desire which is the keynote to the whole of his biological work. In this connection the prose poem, *Die Natur*, [*not* reprinted here] with a translation (pp. 121-124), has special significance. Whatever answer may ultimately be found to the riddle for its authorship,[72] we know from Goethe's own statement,[73] made nearly half a century after the "Fragment," as it was originally called, appeared, that, in looking back over his scientific career, he regarded *Die Natur* as representing the views which he had held in the earlier part of the decade preceding the publication of the *Metamorphose*, and which he considered that he had since outgrown. Throughout the poem runs the thread of an intense awareness of the antithetic and paradoxical attributes characterizing those aspects of the universe which the writer personifies as *Die Natur*. Goethe may well have been for a time overmastered by the consciousness of such contradictions, but his mental bias would not let him rest permanently at this stage; he soon began to seek, and to believe that he had found, a reconcilement of the antithetic elements in existence. His solution was not, however, truly synthetic, since it led him to stress the one, and to absorb the many into it. It is possible to hold that his devotion to the idea of the one led to a certain sacrifice of his intellectual integrity. Hankering, as he did, to regard nature as unified and directional, rather than inconstant and capricious, he came to see her apparent inconsistencies merely as masks for essential oneness. It was from this viewpoint that his morphological work was developed. According to the theory of plant members, which he put forward in the *Metamorphose*, he visualized the indescribably various appendicular organs of plants all as expressions of one form -- the leaf. In his wider study of morphology he went further in the same direction, and he reached the concept of a single *type* in accordance with which everything was fashioned (den Begriff des Typus, nach dem sich alles bildet).[74] Though he made this idea peculiarly his own, he did not originate it. It is a device for figuring out the problems of existence to which those who see these problems on broad lines have frequently resorted.[75] In the *Metamorphose* the type concept is implicit rather than explicit; the word *Urblatt*, for the type leaf, does not

occur.[76] In his other notes and writings the idea of the type is more fully developed, but the meaning which he attached to it defies exact definition; he thought of it as a Proteus that eludes any one form of expression and can only be glimpsed in a piecemeal and paradoxical fashion.[77] Moreover, in trying to convey his views in another tongue, we are faced with the difficulty that in English we have nothing really equivalent to those words with an *Ur* prefix which Goethe employed in this connection *(Urbild, Urtier, Urpflanze,* etc.) . Fortunately the significance of the type concept is revealed in the examples which he cites, rather than in any verbal formulation. He suggests, for instance, that the *Orchidaceae* might be described as monstrous *Liliaceae*;[78] that is to say, he thought of them as a teratological deviation from the *Liliaceae* type. He would, indeed have been pleased with a recent account of an abnormal flower of *Cypripedium*, which was trimerous and perfectly regular.[79] It would be an error to suppose, on the ground of his ideas upon the relation of the flower structure in the *Orchidaceae* and *Liliaceae,* that Goethe thought of the "type" as an ancestral form, which had had actual existence at some previous period, for he was not an evolutionist in the modern sense.[80] On his view the "Urpflanze" could neither be described adequately in words, nor represented pictorially -- an essential limitation which some of his followers unfortunately ignored. His type concept has frequently been equated with the *forms* or *ideas* of Plato,[81] and some of Goethe's expressions may be interpreted as indicating that he so regarded it, but it[82] is doubtful if this identification can be accepted. Hansen[83] is probably right in his opinion that Goethe's "Blatt" is, on the contrary, a conjectural concept, enabling a hypothetical situation to be visualized. On this reading it is recognized as comparable with such terms as atom and molecule, and as thus being merely a tool of thought. From this standpoint, which has much to favor it -- though Goethe himself would by no means have accepted it -- the type concept is seen as having merely provisional status, so that we are justified in discarding it when it has served its turn in leading us to something more adequate. For instance, if we adopt the partial-shoot hypothesis of the leaf -- as representing an advance upon Goethe's thought -- we need no longer postulate a type-phyllome from which all the lateral appendages of the stem have been derived; for on this view

they are not derived *from one another*, but are related merely in so far as they are all incomplete shoots. They are therefore parallel but independent members, rather than divergences from a single primeval leaf form. Goethe in 1784 spoke of "paralleling" organic parts which are alike in their inner nature, but wholly unlike in appearance,[84] but he did not develop this suggestion, nor did he realize that the notion of parallelism might eventually replace his naiver type concept.[85]

In Goethe's eyes the type principle was the clue to the interpretation of animals as well as plants. It was through this principle that in zoology he reached an important factual discovery -- which was not, however, as completely new as he believed it to be[86] -- that of the intermaxillary bone in man.[87] None of Goethe's thinking was ever isolated from his whole mental activity, and the type concept, or, more widely, the idea of *Ur* phenomena, was to him a clue to be followed not in science merely; it was, rather, one of the keys which gave him the freedom of the universe as a whole. He applied this concept to man (*Urmensch*) and even to the landscape which forms his background (*Urlandschaft*). This development of the type concept lies outside out present scope; for a stimulating study of it, the reader may be referred to Humphry Trevelyan's work.[88]

It was not until late in Goethe's life that he came into contact with A. P. de Candolle's cognate ideas. In 1828, F. J. Soret, a Swiss friend, introduced him to de Candolle's *Organographie végétale*, which had been published in the previous year. Goethe was greatly impressed by the doctrine of symmetry there developed, a doctrine which bore some affinity to his own views. He planned a work[89] to include a French version of the *Metamorphose*, and also the chapter in de Candolle's *Organographie*, "Sur la symétrie des plantes," and other representative extracts from this book, and from de Candolle's *Théorie élémentaire* (1813), accompanied by German translations. The work as eventually published was much reduced, and the projected de Candolle section was omitted, but the fact that Goethe had intended to introduce it, shows that he felt no jealous rivalry; on the contrary, he expressed his wonder at the power shown by the Master -- as he calls de Candolle -- in handling an infinity of detail.[90] De Candolle's views had been reached independently, for it is recorded by his son[91] that his father did not

read German, and that he knew nothing of the *Metamorphose* until 1823 -- more than thirty years after its publication -- when a friend sent him an epitome of it in French; he was thus not fully acquainted with it even when he produced the *Organographie* in 1827. Goethe showed no bitterness at this disregard of his work, which was, indeed, eventually more than compensated by the part which de Candolle's pupils played in disseminating the ideas developed in the *Metamorphose*.[92] One is tempted to think that there would have been more effective contact between Goethe and de Candolle if they had been born two centuries earlier, when Latin was the *lingua franca* of scientific men.

De Candolle's morphology centered in the notion of the basic symmetry of all plant forms -- "la symétrie normale ou primitive des êtres."[93] The asymmetry that, in fact, frequently occurs, he regarded as secondary, and as requiring in each case some special explanation. We cannot here trace the history of the symmetry conception; it was not new when de Candolle propounded it, but he was the first to give it full expression. De Candolle's law of symmetry, and Goethe's principle of metamorphosis, were in no way incompatible. They were concerned with the same phenomena, though seen from somewhat different standpoints; each contained something of the truth, though neither was the whole truth. Like Goethe, de Candolle was not far from taking the step which would have set him on the way to the conception of the leaf as a partial shoot; his doctrine would indeed have fitted exactly with the notion of the leaf as a shoot which -- owing to its relation to the parent shoot -- has lost its radial symmetry and retained dorsi-ventral symmetry alone. But for his close adherence to root, stem, and leaf, as rigidly discrete units (organes fondamentaux),[94] which cannot be interpreted in terms of one another, he might have seen how to relate the leaf to the shoot, instead of leaving this feat to be accomplished by his grandson, Casimir, many years later.

So far as we know, de Candolle never concerned himself about the differences between his own mentality and that of Goethe. Goethe, however, with his intense interest in psychological problems, discusses these differences, and their results, in a way which throws light upon his own general attitude to scientific work. In a letter to Soret on April 2, 1818,[95]

Goethe treats de Candolle's work and his own as exemplifying the contrast between analysis and synthesis. He held these two modes of approach to be reciprocal, mutually helpful even in their antagonisms, and equally indispensable both in theory and in practice. Though he knew that analysis was essential, and respected and admired it in de Candolle, it was synthesis to which the whole of his mental and psychical equipment inclined him personally. How deep-seated his feeling for synthesis was, is indicated by his prophecy that poetry and science, which in his day dwelt in total isolation, would eventually come to a happy meeting on a higher plane.[96]

In the fragmentary *Zur Morphologie*, published in 1817, Goethe emphasizes the disadvantages to biology of the analytical approach through chemistry and anatomy. He says that, by this method, the living creature is dissected into its elements, but that from these elements it is impossible to reconstitute and reanimate it.[97] Those today who advocate a holistic or organismal view of life, have often used expressions almost identical with this of Goethe's, but without realizing that he had been there before them.

Goethe's synthetic views share the difficulty which besets holistic interpretations in general -- that they tend to carry the enquirer out of the sphere of science, which, in the stricter sense, is a discipline obtaining its results by the application of methods of a manageable kind. Schiller, in a letter to Goethe written in 1794,[98] points out that to embark on the heroic path of taking all nature together, and seeking in the totality of phenomena for the explanation of the individual, is to reach after a goal which there is no hope of attaining in a lifetime. Goethe's own solution of this difficulty did not lie in the attempt to apply scientific method where he felt it to be out of place, but in the development of symbolic thought. Faced with the manifoldness of phenomena, he tried to reconcile it with his basic idea of the unity of all things, by striving to discern the whole in the tiniest individual thing.[99] Any subject, however small and limited, with which he concerned himself, became for him the microcosm of something universal; it is not surprising that he was conscious of a special appeal in the Old Testament story of Saul, the son of Kish, who went forth to seek his father's asses, and found a kingdom.[100]

Symbolic interpretations of experience came to be more and more important to Goethe, especially in the latter part of his life.[101] Such interpretations involve a special stress upon *comparison*, and Goethe's great service to morphology lay in the recognition that its basis must be essentially comparative. This comparative way of viewing nature contrasts with the method that is "scientific" in the rigid sense, and consists in the attempt to treat biological phenomena on mechanical lines. The latter method had little attraction for Goethe; he wrote that "The application of mechanical principles to organic Nature has only made us the more aware of the wholeness of the living being."[102] In order to appreciate Goethe's attitude, it is necessary to consider how his ideas were related to "explanation," as this is generally understood in science. The word "explanation" may be held to correspond to the German word "Erklärung," Troll's definition[103] of which includes setting forth the cause of a phenomenon, or finding the orderly place for a special fact in a casual sequence. This idea of explanation -- as equivalent to the locating of the thing-to-be-explained in a chain of causation -- was alien to Goethe's mind; he held the view that "The thinker makes a great mistake when he asks after cause and affect; they both together make up the indivisible phenomenon."[104] He recognized, however, that to range appearances under the various forms of causation was an activity arising inevitably from the construction of the human mind, and he was prepared to regard this as justifiable, even when it fell outside his own scheme of things. For instance, in discussing Vaucher's work, Goethe speaks of this author's explanations of physiological phenomena in terms of purpose, as being foreign to his own outlook, but adds that he quarrels with no one who chooses to adopt the standpoint of teleology.[105]

For the type of explanation based on cause and effect, Goethe substituted a process that can be described only by the untranslatable German word, "Darstellung," which may be defined, approximately, as the demonstration or representation of an object, brought into relation with others in such a way that its significance is revealed.[106] Goethe himself spoke of morphology as a discipline which "nur darstellen und nicht erklären will."[107]

We know that Goethe's actual visual impressions were peculiarly intense, and greatly influenced his mode of thought; indeed, his inclination always drew him to "picture thinking." For this way of apprehending nature, Troll[108] uses the expression "intuitive Anschauung," which might be called, "thinking with the mind's eye"; it lies midway between sensuous perceptions reached through bodily sight, and the abstract conceptions of the intellect. Actually to "see," as it were, the solution of a problem, is, to most biologists, an experience as rare as it is delightful; but Goethe's mind worked in this way all the time. He even made a vigorous and prolonged attempt to apply the "Anschauung" method to physics, an attempt which was obviously foredoomed to failure. He tried to tackle the problems offered by color,[109] on the assumption that such physical questions could be studied non-mathematically. Even here, however, it is possible to hold that his attitude -- fantastic as it may appear when judged from the standpoint of modern physics -- was not entirely devoid of value. There is a modicum of truth underlying the picturesque exaggeration of Croce's statement that Goethe's "emerging from a century intoxicated with mathematics, understood and had the courage to assert that mathematics do not lead to the knowledge of reality, and that in them there is nothing exact but their own exactness."[110]

Goethe was not at home in thought which was purely abstract; he says of himself that for philosophy in the strict sense he had no capacity (kein Organ).[111] Schiller[112], with his keener power of thought on the philosophic plane, criticized Goethe as apprehending all too much through the senses. Despite such drawbacks, Goethe's mode of approach had, and still has, a special and original quality; for in including and emphasizing visual perception, and relating it to thought on the non-tangible plane, it points the way towards a reconcilement of the purely abstract with the purely sensuous. Early in this introduction, we spoke of the vexed question of Goethe's scientific status. After a consideration of his biological thought, this question still remains fraught with difficulty, for the catholicity of his mind, and the kaleidoscopic character of his activity, defy neat labelling. As a botanist, he began with a simple utilitarian interest in plants; he passed through a brief period in which he studied the multiplicity of the plant world from the standpoint of the descriptive naturalist; this was succeeded by a phase in

which his mind was entirely possessed by comparative morphology, a subject to which the value of his contribution, and the inspiration which later workers have derived from it, are undeniable; and, finally, by a transition natural to his mental growth, he reached a stage in which his morphological thought reached out to the reconciliation of the antithesis between the senses and the intellect, an antithesis with which traditional science does not attempt to cope. It has been suggested by a literary critic that Goethe was "a great poet who *grew out* of poetry."[113] Approaching him, as we have done here, through the medium of his plant studies, we may perhaps offer the comparable conclusion, that Goethe was a great biologist, who, in the long run, overstepped the bounds of science.

A NOTE ON TRANSLATIONS: -- Two French translations of the *Versuch die Metamorphose der Pflanzen zu erklären* (1790) were published in Goethe's lifetime, both by Swiss botanists who had been pupils of de Candolle. The earlier, by F. Gingins-Lassaraz, appeared in 1829;[114] in Goethe's own copy of this work there are manuscript notes pointing to its infidelity and incompleteness.[115] The second translation, by F. J. Soret, came out two years later: *Essai sur la Métamorphose des Plantes...suivi de notes historiques*, Stuttgart, 1831.[116] Soret, who criticized Gingins-Lassaraz as having used nineteenth-century technical terms, which were an anachronism,[116] described his own version as "travallée avec soin sous les yeux même de l'auteur." Goethe was enthusiastic about this translation, which he spoke of, while it was in progress, as being "more and more felicitous";[117] but it is too free to be as helpful as might have been expected in the interpretation of obscure points. It seems probable that Goethe, in his old age, did not, in reality, criticize it intensively, and also that he gave Soret considerable latitude, because he held that the differences between French and German mentality made it necessary for his ideas to be presented in a somewhat different guise when they were intended for a French audience. He feared that a nation, which demands in everything entire clarity of expression and thought, might suspect him of falling into mystic reveries if he wrote for them in the style which it was natural for him to use in addressing his compatriots.[118]

Five years after Goethe's death, another French translation appeared from C. F. Martins.[119]

It was not until 1863 that a version was published in English: *Essay on the Metamorphosis of Plants*, Translated by Emily M. Cox; with Explanatory Notes by Maxwell T. Masters (*Journal of Botany*, vol. 1, pp. 327-45, 360-74, 1 pl.). My own translation, which follows this Note, was made independently, but, when it was completed, I compared it throughout with the *Journal of Botany* version, and, wherever the latter seemed to me to convey the sense more accurately than my own, I modified mine in accordance with it.

Another English translation appeared in the *Notes and Correspondence of the Anthrosophical Agricultural Foundation*, vol. 4, No. 8, April 1937. I am indebted to Mr. W. T. Stearn for showing me this version in the year of its publication, but I have not been able to consult it during the preparation of my own rendering. It is described as based on the *Journal of Botany* translation, and on another by Mrs. Mirbt; it has an introduction by G. Kaufmann.

Those who are curious in such matters may find amusement in certain specimens of poetical versions which appeared in the *Gardener's Chronicle*, vol. 4, 1844, pp. 117 and 133.

In translating the title of Goethe's book, I have used the word "Attempt," instead of "Essay," for "Versuch," because I believe that "Attempt" more nearly expresses Goethe's intention. Batsch's introduction to botany, which was published three years before Goethe's work, and which he cites, may have suggested the form of the title, for it is called *Versuch einer Anleitung zur Kenntniss und Geschichte der Pflanzen*. Batsch's work is a solid and detailed textbook; it cannot be called an "Essay," if the word is used in the sense which has in general been attached to it from the days of Montaigne onwards. It seems safe to assume that Goethe, in his first edition, followed Batsch in employing the term "Versuch" in the modest sense of "something attempted" -- a sense which the English word "essay" conveyed in former days, but which it has now lost. In Soret's French and German issue of 1831, the title losing something of its humility, is changed to *Versuch über die Metamorphose der Pflanzen*; here the word "Essay" seems to be the best equivalent for "Versuch," and "Essai" is used in the French translation.

In the following version, those footnotes, or parts of footnotes, which are not in the original text, are initialled (A. A.). Readers who wish for fuller annotation will find it in Troll ed., p. 455 *et seq.*

TRANSLATION

An
Attempt to Interpret
the Metamorphosis
of Plants

by
J. W. von Goethe

1790

J. W. von Goethe
Herzoglich Sachfen-Weimarifchen Geheimenraths

Versuch
die Metamorphose
der Pflanzen
zu erklären

Gotha,
bey Carl Wilhelm Ettinger.
1790.

"I am indeed not unaware that this path is obscured by clouds, which will pass over from time to time. Yet these clouds will easily be dispersed when it is possible to make the fullest use of the light of experience. For Nature always resembles herself, although she often seems to us, on account of the inevitable deficiency of our observations, to disagree with herself." (Linnaeus, Anticipation in Plants, Dis. I).[120]

INTRODUCTION

#1

Anyone who pays a little attention to the growth of plants will readily observe that certain of their external members are sometimes transformed, so that they assume -- either wholly or in some lesser degree -- the form of the members nearest in the series.

#2

Thus, for example, the usual process by which a single flower becomes double, is that, instead of filaments and anthers, petals are developed; these either show a complete resemblance in form and color to the other leaves of the corolla, or they still carry some visible traces of their origin.

#3

If we note that it is in this way possible for the plant to take a step backwards and thus to reverse the order of growth, we shall obtain so much the more insight into nature's regular procedure; and we shall make the acquaintance of the laws of transmutation, according to which she produces one part from another, and sets before us the most varied forms through modification of a single organ.

#4

The underlying kinship of the various external members of the plant, such as the leaves, calyx, corolla, and stamens, which develop after one another, and, as it were, from one another, has long been recognized by naturalists in a general way; it has indeed received special attention, and the process, by which one and the same organ presents itself to our eyes under protean forms, has been called the *Metamorphosis of Plants*.

#5

This metamorphosis displays itself in three modes: *normal, abnormal, and fortuitous.*

#6

Normal metamorphosis may also be called *progressive*: for it is that which may be perceived always working step by step from the first seed leaves to the final development of the fruit. Through the change of one form into another, it passes by an ascent -- ladder-like in the mind's eye -- to that goal of nature, sexual reproduction. It is this progression which I have studied attentively for a number of years, and which I shall attempt to elucidate in the present essay. This being our standpoint, we will consider the plant, in the following demonstration, only in so far as it is an annual, and by continuous progression from the seed up to the fructification.

#7

We may give the name of *retrograde* metamorphosis to that which is *abnormal*. As in the normal course, nature hastens forward to her great end, so in the abnormal, she takes one or more steps backwards. As she there, with irresistible impulse and the full exertion of her might, fashions the flowers and prepares them for the works of love; so here she slackens, as it were, and leaves her creation before it reaches its goal, in an undetermined and powerless condition. Though in this state it is often agreeable to our eyes, in its true inwardness it is feeble and ineffectual. From our acquaintance with this abnormal metamorphosis, we are enabled to unveil the secrets that normal metamorphosis conceals from us, and to see distinctly what, from the regular course of development, we can only infer. And it is by this procedure that we hope to achieve most surely the end which we have in view.

#8

We will, on the other hand, avert our eyes from the third kind of metamorphosis, which comes about *contingently*, as a result of external causes, especially through the action of insects; for this phenomenon might frustrate our purpose by diverting us from the direct path which we ought to follow. Perhaps there will be an opportunity to speak elsewhere of these excrescences, which, though monstrous, are still subject to definite limitations.

#9

I have ventured to draw up the present work without giving illustrative plates, which however, in many respects might seem necessary. I propose to reserve them for the sequel, which can be done the more easily, since enough material is left over for the elucidation and further development of the present short and merely preliminary essay. It will not then be necessary to produce so formal a treatise as this one. I shall have the opportunity of bringing forward much cognate matter; and passages extracted from authors of a like way of thinking will then find their natural place. Especially I will not fail to make use of any suggestions from the experts who today are the glory of this noble science. It is to them that I commit and dedicate these pages.

I. CONCERNING THE SEED LEAVES

#10

Since we have undertaken to observe the sequence of stages of plant growth, let us turn our attention forthwith to the plant at the moment when it germinates. At this stage we may easily and exactly recognize the parts which directly belong to it. It leaves its husks more or less completely in the earth; these we will not now investigate. In many cases, when the root has anchored itself in the soil, the plant brings forth into the light the first organs of its upper growth, which were already present, hidden within the seed coat.

#11

These first organs are known under the name of *cotyledons*. They have also been called seed valves, kernel pieces, seed lobes, and seed leaves; these names are an attempt to denote the various forms which the cotyledons assume.

#12

They often appear shapeless, crammed, as it were, with crude matter, and as much extended in thickness as in breadth;[121] their vessels are unrecognizable, and scarcely to be distinguished from the mass as whole. These cotyledons bear scarcely any resemblance to a leaf, and we may be misled into taking them for organs belonging to some special category.

#13

Nevertheless in many plants they approach leaf form; they increase in area and become thinner; when exposed to light and air they assume a deeper green; the vessels which they contain become more recognizable, and more similar to the veins of a leaf.

#14

Finally they appear before us as true leaves, the vessels of which are capable of the finest development. Their resemblance to the succeeding leaves prevents our taking them for special organs; we recognize them, rather, as the first leaves of the stem.

#15

But since we cannot think of a leaf without a node, or a node without a bud, we may be allowed to conclude that the point where the cotyledons are attached is the veritable first nodal point of the plant. Confirmation of this view is afforded by those plants which put forth young buds immediately at the base of the cotyledonary wings, and produce complete shoots from the first nodes, as the horse bean (*Vicia Faba* L.) is wont to do.

#16

The cotyledons are generally twinned, and this leads us to make an observation, the significance of which will be more fully appreciated at a later point. This is that the leaves of this first node are often paired when the succeeding leaves of the stem stand *alternately*; there is here an approach and association of parts which nature, later in the sequence, disjoins and separates from one another. This is still more noticeable when the cotyledons take the form of numerous small leaves assembled round the common axis, while the stem, developing gradually from their midst, bears the succeeding leaves singly, round about itself. This can be observed to perfection in the growth of conifers. Here the wreath of needles forms, as it were, a calyx. We shall have to recall these cases in connection with similar phenomena which we shall meet later.

#17

We will not now occupy ourselves with the single cotyledons of indefinite form belonging to those plants which germinate with one leaf.

#18

We will, however, notice that even the most leaf-like cotyledons themselves are always relatively undeveloped as compared with the later leaves of the shoot. Their outline, especially, is extremely simple, and bears as little trace of indentations as their surfaces do of hairs or other vessels (Gefässe)[122] characteristic of the mature leaf.

II. DEVELOPMENT OF THE STEM LEAVES FROM NODE TO NODE

#19

We are able now to study accurately the successive formation of the leaves, since the progressive operations of nature all take place, step by step, under our eyes. A variable number of the succeeding leaves are often already present within the seed, and lie enclosed between the cotyledons; while still in their folded condition they are known under the name of the plumule. The relation of their form to that of the cotyledons and of the following leaves differs in different plants, but they generally diverge from the cotyledons in being expanded and thin in texture; on the whole fashioned as typical leaves; fully green in color; and attached to an obvious node. Their relationship to the later stem leaves is indubitable, but they are commonly inferior to them in the fact that their periphery or margin has not reached its full elaboration.

#20

The leaf shows a continuous development from node to node, as the midrib elongates, and the lateral veins arising from it stretch out more or less on either hand. The various characters of the nervation are the principal cause of the multifarious forms met with in leaves. Leaves may be indented, deeply incised, or formed of many leaflets; in the last case they prefigure complete small shoots. The date palm affords a striking example of such graded diversification of the simplest leaf form. In a sequence of several leaves, the midrib is carried progressively further into the lamina; the fan-like simple leaf becomes torn and divided; and the end result is a highly complex leaf, vying with a branch.

#21

As the leaf itself arrives at the perfection of its form, so the leaf stalk also develops correspondingly; it may either make a continuous whole with its leaf, or it may form a distinct stalklet, easily detachable at a later stage.

#22

We see in various plants, for example the orange tribe,[123] that this independent leaf stalk may also have a tendency to transform itself into a leaf-like form. The organization of such leaf stalks will in the sequel suggest some considerations to us, which we will put aside for the present.

#23

Neither can we now enter upon a special investigation of stipules; we only remark in passing that, especially when they form part of the leaf stalk, they also become remarkably transformed in the course of its further change.

#24

Now as the leaves owe their first nourishment principally to the more or less modified watery fluid which they draw from the stem, so they are indebted to the air and the light for their main development and elaboration. As we find the cotyledons, produced within the closed seed coat, charged as it were with a crude sap only, and organized and developed scarcely at all, or merely in a rough fashion; so the leaves of plants which grow under water are of less perfect organization than those exposed to the open air. Again, the same plant species develops smoother and less highly perfected leaves when it grows in low and damp places; if on the contrary it is transferred to a higher situation, it produces leaves which are rough, hairy, and more elaborately formed.

#25

The vessels[124] which form the skin of the leaf, and which arise from the ribs and feel their way towards one another by their tips, are similarly influenced; their anastomosis, if not altogether caused, is at least much promoted by the more subtle kinds of gas. We are inclined to ascribe to lack of complete anastomosis the fact that the leaves of many plants which grow under water are thread-like or antler-like. The mode of growth of the water buttercup (*Ranunculus aquatilis* L.)[125] affords us clear evidence on this point, since its leaves produced under water have thread-like ribs, while those

developed above the water surface are formed with fully anastomosed and entire blades. Indeed the transition can be accurately traced in leaves of this plant which are partly anastomosed and partly thread-like.

#26

It has been learned experimentally that the leaves of plants absorb different gases and combine them with their internal moisture; nor does any doubt remain that they return these refined saps to the stem, and thus greatly promote the growth of the neighboring buds. The kinds of gas developed from the leaves of many plants, and also from the cavities of reeds,[126] have been investigated with convincing results.

#27

We observe in various plants that one node springs from another. In stems which are closed at the nodes,[127] as in cereals, grasses, and reeds, this is obvious to the eye; but it is less conspicuous in other plants which have a hollow center throughout, and appear to be filled with a pith or rather a cellular tissue. The rank, among the other anatomical regions of the plant, formerly held by the so-called pith is now however disputed,[128] and, as it seems to us, on excellent grounds. Its apparently predominant influence in growth is denied, while all impetus and developmental force is, on the other hand, ascribed unhesitatingly to the inner face of the second cortex -- the so-called *liber*. It thus becomes more convincing that an upper node -- since it arises from the one below, and receives the sap by its mediation in a finer and more filtered state, improved by the action of the preceding leaves -- must develop more perfectly and convey more delicate juices to its own leaves and buds.

#28

Since now the cruder saps are continually drained in this manner, and give rise to purer -- the plant meanwhile perfecting itself step by step -- the period prescribed by nature is finally reached. At last we see the leaves in their greatest expansion and development, and soon afterwards we become aware of a new aspect which warns us that the epoch which hitherto we have been studying is past, and a second is approaching -- the epoch of the *flower*.

III. THE TRANSITION TO THE FLOWERING PHASE[129]

#29

We see the transition to anthesis come to pass either *relatively rapidly or relatively gradually*. In the latter case we commonly notice that the stem leaves begin to draw in, as it were, from the periphery, and especially to lose their diverse marginal division, while, on the other hand, they show some expansion in their basal regions, where they are connected with the stem. At the same time we see that, even if the stem interval from node to node does not elongate markedly, nevertheless it is much more delicately and slenderly formed than in its earlier state.

#30

It has been observed that copious nourishment hinders the production of the inflorescence of a plant, while a moderate or indeed scanty supply of food hastens it. The action of the stem leaves, considered above, shows itself here still more clearly. So long as cruder saps are still to be carried away, so long must there be production of those organs which are capable of fulfilling this need. If excessive nourishment is forced upon the plant, this operation must be continually repeated, and flowering is thus rendered well-nigh impossible. If, on the other hand, the plant is deprived of food, this natural process is facilitated and shortened; the foliar organs are refined, the operation of the unadulterated saps becomes purer and stronger, and the transformation of the parts is rendered possible and makes unimpeded progress.

IV. FORMATION OF THE CALYX

#31

We often see the change to the flowering phase occur rapidly, and in this case the stem, above the node of the uppermost leaf, suddenly becomes tall and slender, while several leaves are gathered together at its apex, grouped around a center.

#32

It may, it seems to us, be proved most clearly that the leaves of the calyx are the same organs as those which up to the present have developed as stem leaves, but are now, often in very different guise, collected round a common center.

#33

We have already among cotyledons noticed a similar operation of nature, and have seen several leaves, and thus clearly several nodes, collected round a point and approximated. The conifers, when they develop from the seed, show a radiating wreath of unmistakable needles, which, unlike the generality of other cotyledons, are already highly developed. We thus see, in the first infancy of this plant, an indication, as it were, of that power of nature through which, at a greater age, inflorescence and infructescence will be produced.

#34

Further we see in various flowers unaltered stem-leaves collected into a kind of calyx immediately beneath the corolla. Since their form is completely characteristic, we need only, in proof of their being leaves, appeal to ocular evidence and to botanical terminology, which has distinguished them by the name of floral leaves, *Folia floria*.

#35

We have to observe with greater attention the case already mentioned, in which the transition to the inflorescence occurs *gradually*. Here the stem leaves approach one another little by little, become transformed, and by degrees, as it were, pass into the calyx, as it may easily be observed in the calyx[130] of the composites, especially the sunflowers and the marigolds.

#36

This faculty of nature, which assembles a number of leaves around a center, may be observed to bring about an even more intimate union, thus making these collected and modified leaves still less recognizable; for it unites them between themselves -- sometimes completely, but often only partially -- inducing concrescence of their lateral margins. The leaves -- so closely crowded and pressed against one another -- are most intimately in contact in their embryonic condition; they anastomose through the influence of the extremely pure sap present by this time in the plant, and appear before us as the bell-shaped or so-called one-leaved (monosepalous) calyx, which reveals its compound origin by the fact that its upper margin is more or less toothed or incised. We can find ocular evidence of this if we compare a

number of deeply cut calyces with those that are many-leaved, especially when the calyces of various composites are exactly considered. We shall see, for example, that the calyx of the marigold, which in systematic descriptions is called *simple* and *much divided*, consists, in reality of many concrescent and superposed leaves, into which, as we have already mentioned, the contracted stem leaves pass, as it were, almost insensibly.

#37

In many plants there is constancy in the number and form in which the sepals, whether free or fused, and succeeding members are arranged round the stalk as an axis. On this constancy depends, in great part, the progress, the trustworthiness, and repute of botanical science, which we of late have seen increasing more and more. In other plants the number and structure of these members is not equally constant, but even this inconstancy has been unable to baffle the delicate powers of discrimination of the master workers in this science; their endeavor has been by exact diagnosis to limit these anomalies of nature, as it were, to a narrower sphere.

#38

In this way, then nature formed the calyx: she *connected together* around a center several leaves and consequently several nodes, generally according to a certain definite number and plan; these leaves and nodes she would otherwise have produced *successfully and at some distance from one another.* If the flowering had been inhibited by the intrusion of superfluous nourishment, these leaves would have been spaced out, and would have appeared in their earlier form. Thus in the calyx nature produces no new organ, but she unites and modifies only the organs already known to us, and in this way achieves a step towards the goal.

V. FORMATION OF THE COROLLA

#39

We have seen that the calyx owes its origin to elaborated saps, which are engendered by degrees in the plant, and that it is thus in its turn adapted for the production of a future organ of a further refinement. This idea can be confirmed when we interpret the process on purely mechanical grounds. For how extremely delicate, and suited to the finest filtration, those vessels must become, when they, as we have seen above, are in the closest contact and appressed to one another.

#40

We may observe the transition from calyx to corolla in more than one case; for although the color of the calyx is still usually green, and remains similar to the color of the stem leaves, yet it often changes in one or other of its regions -- at the apices, margins, or back, or over its inner surface -- while the outer still remains green; and we always see an increase of delicacy associated with this coloration. In this way ambiguous calyces come into being, which may equally well be taken for corollas.

#41

We have now remarked that from the cotyledons onwards there is a great extension and elaboration of the leaf, affecting its periphery in particular. Thence to the calyx there is a contraction of the outline, while, with the development of the corolla, we notice that a phase of expansion again sets in. The petals are generally larger than the sepals, and it is to be observed that the organs which were in a state of contraction in the calyx, at the stage now reached expand themselves as petals through the influence or purer saps, filtered through the calyx and in a high degree refined. They assume the appearance of entirely different organs, and their exquisite texture, their color, and their scent, would quite obscure their origin for us, if it were not that in various exceptional cases we can spy out nature's ways.

#42

So, for example, within the calyx of a pink, a second calyx is frequently found, which in part is fully green, and belongs to the type of the monophyllous toothed calyx, while in part it is laciniated, and, at its apices and margins, transformed into genuine beginnings of petals -- delicate, expanded and colored. Through such a case we once more clearly recognize the relationship of the corolla to the calyx.

#43

The relationship of the corolla to the stem leaves is demonstrated to us in more than one manner; for in various plants stem leaves occur which are already more or less tinted, long before they approach the inflorescence, while others, in the neighborhood of the inflorescence, are completely colored.

#44

It also frequently happens that nature proceeds direct to the corolla, as it were skipping the calyx. In this case we likewise have the chance of observing that stem leaves may pass into petals. So, for example, an almost completely developed and colored petal may often be found on the stem of a tulip. A still more remarkable case is that in which such a leaf is half green, with its green half, which belongs to the stem, remaining attached thereto, while its colored half is carried up with the corolla, so that the leaf is torn into two parts.

#45

It is a very probable idea that the color and scent of the petals are to be attributed to the presence in them of the male fertilizing substance.[131] Probably this substance occurs in them in a state in which it is not yet sufficiently isolated, but mixed and diluted with other juices. The beautiful phenomena of color lead us to the conception that the material wherewith the petals are filled, though indeed it has achieved a high degree of purity, yet still has not reached the highest grade, in which it appears to us white and colorless.

VI. FORMATION OF THE ANDROECIUM

#46

The theory suggested in the preceding paragraph seems still more probable when we consider the near relationship of petals and androecium. Were the relationship of all the other parts to one another so obvious, so generally observed, and so indubitably settled, the present treatise might be held to be superfluous.

#47

Nature in some cases shows us this transition in the normal course of development, *e.g.* in *Canna*, and various plants of this family. A true petal, little changed, contracts in its upper margin, and an anther, in connection with which the rest of the petal takes the place of a filament, makes its appearance.

#48

In flowers which are often double, we can observe this transition in all its stages. In several kinds of rose, within the fully developed and colored petals, there are others which are contracted, sometimes in the middle and sometimes at the side; this contraction is caused by a little callosity, which appears as a more or less complete anther, while, in a degree corresponding to the degree of contraction, the leaf approaches the simpler form of a stamen. In some double poppies, fully developed anthers are borne upon little-changed petals of the strongly double corolla, while in others, anther-like callosities induce more or less contraction of the petals.

#49

If all stamens are changed into petals, the flowers become sterile, but if in a flower, while it becomes double, staminal development still occurs, fertilization takes place.

#50

And so an androecium arises, when the organs which we have hitherto seen expanded as petals, reappear in a highly contracted and, at the same time, a highly refined condition. The opinion propounded above is thus once more confirmed, and we are made more and more aware of this alternating process of contraction and expansion, whereby nature ultimately attains her end.

VI. NECTARIES

#51

Abrupt as is the transition in many plants from the corolla to the androecium, yet we notice that nature does not always make the passage in a single stride. On the contrary, she produces intermediate organs, which in form and function sometimes approach one member and sometimes the other. Although the structure of these intermediate organs varies greatly, yet they can generally be brought together under the one conception that they are *gradual transitions between the petals* [132] *and the stamens.*

#52

Most of the variously formed organs, which Linnaeus distinguished with the name of Nectaries, may be grouped under this definition; and here

we find an additional reason for admiring the keen insight of that extraordinary man, who, without having a quite clear idea of the function of this part, yet trusted to a presentiment, and took the risk of calling by the same name organs which were very diverse in appearance.

#53

Various petals show their relationship with the stamens by the fact that, without markedly changing their form, they bear little grooves or glands, which secrete a honey-like sap. That this is a fertilizing fluid, though still imperfect and incompletely determinate, may be conjectured from the considerations already advanced, and this conjecture will reach a still higher degree of probability, for reasons which we will bring forward later.

#54

The so-called nectaries may also appear as independent members, and then they sometimes approach petals in their structure, and sometimes stamens. For example, the thirteen rays of the nectaries of the grass of Parnassus (*Parnassia*), with their corresponding number of red globules, are closely similar to the stamens. Others show themselves as filaments without anthers, as in *Vallisneria* and *Fevillea*. We find them in *Pentapetes* regularly alternating with the stamens in one whorl, but foliar in form; in systematic descriptions they are called petal-shaped emasculated filaments (*filamenta castrata petaliformia*). Just such forms, oscillating between the categories,[133] are seen in *Kiggellaria* and the passion flower.

#55

Those peculiar organs -- *coronas* -- likewise seem to us to deserve the name of nectaries, in the sense defined above. For if the formation of petals is brought about through an expansion, so the corona is formed, on the contrary, through a contraction -- that is to say, in the same way as the stamens. Thus we see smaller, restricted coronas succeeding the completer, more extended corollas, as for example in narcissus, oleander (*Nerium*), and agrostemma (*Lychnis coronaria* Desr.).

#56

Yet other still more striking and remarkable transformations of petals are to be seen in different genera. We notice in various flowers that their petals, on the inner surface at the base, have a small hollow, which is filled

with a honey-like sap. This pit, when it becomes deeper in other genera and species, produces a spur or horn-like prolongation from the back of the petal, and the form of the rest of the petal is correspondingly more or less modified. We may observe this particularly in various species and varieties of the columbine (*Aquilequia*).

#57

This organ is found in the highest degree of modification, for example, in monkshood (*Aconitum*), and love-in-a-mist (*Nigella*), in which, however, a little attention reveals its foliar character; in *Nigella*, especially, the nectaries readily grow out again into petals, and the flowers become double through their transformation. In *Aconitum*, on careful inspection, the similarity of the nectaries to the hooded petals which enclose them can be detected.

#58

Having propounded the idea that the nectaries are approximations of the petals to the stamens, we may now take the opportunity to make some remarks about irregular flowers. So, for example, the five outer leaves of *Melianthus*[134] may be considered as true petals, but the five inner may be described as a corona, consisting of six nectaries, of which the uppermost approaches most nearly to petal form, while the furthest divergence is shown by the lowermost, which is indeed already called a nectary. In just the same sense, the keel (*carina*) of the papilionaceous flower may be called a nectary, since it is one amongst the petals which most nearly approaches stamen form, and departs very widely from the leaf shape of the so-called standard (*vexillum*). In this matter we can quite easily explain the brushlike bodies which are found attached to the extremity of the keel in some species of milkwort (*Polygala*), and we can come to a clear idea as to the category to which this keel should be assigned.

#59

It is surely unnecessary to make the emphatic reservation that the intention of these remarks is not to introduce confusion into a subject which has been already subdivided and pigeon-holed by the efforts of observers and systematists. The writer wishes only to make the variations of plant form more comprehensible through the considerations here advanced.

VII. FURTHER NOTES ON THE ANDROECIUM

#60

Microscopic observations decide beyond all doubt that the reproductive organs of plants, like their other parts, are produced by means of the spiral vessels. We thence deduce an argument for the inner identity of the various members of the plant, which hitherto have appeared to us in such multifarious forms.

#61

Now since the spiral vessels lie in the center of the sap-vessel-bundles, and are enclosed by them, we may picture the condition of strong contraction somewhat more exactly if we imagine the spiral vessels -- which appear to us indeed as elastic springs -- in their state of utmost energy; they are then dominant, whereas the expansion of the sap-vessels is subordinated.

#62

The abbreviated vascular bundles can now extend no more; they can no longer seek out one another, and no longer form a network through anastomosis; the tubular vessels, which otherwise fill up the interstices of the network, can no longer develop. All factors which have caused the expansion of the stem leaves, sepals, and petals, vanish completely at this point, and a weak and extremely simple filament arises.

#63

The delicate membranes of the anther, between which the excessively tender vessels come to an end, are scarcely able to develop. If we now admit that at this stage those very vessels, which would otherwise have elongated, broadened, and again sought one another out, are at present in an extremely contracted condition; if we now see the highly elaborated pollen proceed from them, which compensates through its activity for what the vessels which produce it have lost in expansion; if it is at last set free and seeks out the female organ, which, through a natural correlation, occurs in the neighborhood of the stamens; if it firmly adheres to this organ and communicates its influence to it: there is nothing then to prevent our calling the union of the two sexes an immaterial anastomosis, and believing that, at least for a moment, we have brought nearer together the concepts of growth and of reproduction.

#64

The delicate substance which develops in the anthers appears to us as a powder; but these pollen-grains are only vessels in which an extremely fine sap is stored. Hence we agree with the opinion of those who hold that the sap is imbibed by the pistils to which the pollen-grains adhere, and that thus fertilization is brought about. This is the more probable since some plants secrete no pollen, but only a mere fluid.

#65

We recall to ourselves at this point the honey-like sap of the nectaries, and its probable relationship with the elaborated fluid of the seminal globules. Perhaps the nectaries are organs the function of which is preparation; perhaps their honey-like moisture is absorbed by the stamens, made more specific, and worked up fully -- an opinion which is the more likely since after fertilization this sap is no longer observable.

#66

We may just notice in passing that in some cases filaments, and, in others, anthers are concrescent, and offer us the most wonderful examples of the anastomosis and union of plant members which in their origin were truly distinct -- a feature to which we have already more than once alluded.

IX. FORMATION OF THE STYLE

#67

As up to the present I have endeavored as far as possible to make clear the inner identity of the various successively developed plant members, despite the very great deviations in their external form; so it will readily be conjectured that my object at this point is to explain the structure of the female organ in the same way.

#68

We will first of all consider the style apart from the fruit, as we indeed often find it in nature; and we can do this the more readily since in this form it shows itself distinct from the fruit.

#69

We notice, then, that the style remains at that stage of growth which characterizes the stamens. We were able in fact to observe that the stamens

originated through contraction. The styles are often in the same case, and we find them, if not always of similar dimensions to the stamens, still only to a small extent longer or shorter. In many examples the style is almost like a filament without an anther, and the relationship of their external form is closer than that of the other members. As they are both produced from spiral vessels, we see the more clearly that the female member has as little claim as the male to be regarded as an organ belonging to a special category; and if through this consideration we get a real insight into its exact relationship with the male, so we find the idea that fertilization is a form of anastomosis the more pertinent and enlightening.

#70

We very often find the style produced by the concrescence of several distinct styles, while the members of which it consists can scarcely be distinguished, for not even at the tip are they always separated. This process of concrescence, the operation of which we have often noticed, is here even more possible than elsewhere; indeed it cannot but happen, since the delicate rudiments, before their development is completed, are compressed one against another in the midst of the flower, and may form the most intimate connections between themselves.

#71

Nature shows us more or less clearly in various normal cases, the close relationship of the style with the preceding parts of the flower. So, for example, the pistil[135] of iris with its stigma presents to our eyes the complete form of a petal. The umbrella-shaped stigma of *Sarracenia* does not reveal itself so strikingly as compounded of several leaves, but its green color does not discredit the idea. And with the help of a lens we find that various stigmas, such as those of crocus and *Zannichellia*, take the form of complete monophyllous or polyphyllous calyces.

#72

In retrograde development, nature often shows us the case of styles and stigmas being again changed into petals; *Rannunculus asiaticus*, for example, becomes double by transformation of the stigmas and pistils of the female organ into veritable petals, while the stamens directly under this corolla are often unchanged. Some other significant instances will be cited below.

#73

We may recapitulate here the remarks made above, that styles and filaments represent corresponding phases of growth, and thereby once more illustrate the principle of alternating expansion and contraction. From the seed to the fullest development of the stem leaves, we first noticed an expansion. After this we saw the calyx arise through a contraction; the petals through an expansion; the sexual organs once more through a contraction; and we shall soon become aware of the extreme of expansion in the fruit, and the extreme of concentration in the seed. In these six steps nature in unresting sequence completes the eternal work of the bisexual reproduction of plants.

X. CONCERNING THE FRUITS

#74

We shall now have to observe the fruits, and we shall soon convince ourselves that they have the same origin as the other organs, and are subject to the same laws. We are speaking particularly of those seed-vessels which nature forms to enclose the so-called covered seeds -- or, rather, from the inner surface of which she develops a larger or smaller number of seeds as the result of fertilization. That these seed-vessels are likewise to be explained from the nature and organization of the members hitherto considered, can also be shown in a few words.

#75

Retrograde metamorphosis, again, brings this law of nature home to us. So, for example, in the pinks -- flowers which are well known and loved for their very degeneracy -- it may often be noticed that the seed-capsules change back into calyx-like leaves, and that the styles shorten correspondingly. Indeed pinks occur in which the seed-vessel has changed into a calyx, real and complete, while its apical teeth still bear the delicate remains of the styles and stigmas, and, from the interior of this second calyx, a more or less perfect corolla is produced in place of the seeds.

#76

Further, nature has herself in very diverse ways revealed to us, in forms regularly and constantly recurrent, the fruitfulness which lies concealed

in the leaf. So the modified, but still completely recognizable, leaf of the lime tree, produces from its midrib a little stalk bearing a complete flower and fruit. In the butcher's broom (*Ruscus*) the manner in which flowers and fruit are borne on the leaves is still more striking.

#77

The direct fertility of the stem leaves in the ferns strikes one as still more intense, and as almost monstrous. These leaves through an inner impulsion, and perhaps without the definite interaction of two sexes, develop and shed countless seeds, or rather gemmae, capable of growth. Here a leaf vies in fruitfulness with a spreading plant, or with a large and branching tree.

#78

Bearing these observations in mind, we cannot fail to recognize the leaf nature of the seed-vessels -- notwithstanding their various forms, their special modification, and their relations among themselves. So, for example, the legume would be a simple folded leaf concrescent by its margins, while siliquas would consist of several leaves, superposed and fused. Compound seed-vessels would be explained as consisting of several leaves united round a middle point, their inner faces open towards one another, and their margins united. We may convince ourselves of this by observing the appearance presented when such aggregated capsules spring apart after ripening, since each member then reveals itself as an opened pod or siliqua. Moreover a similar process regularly occurs in different species of one and the same genus; for example, the fruit capsule of *Nigella orientalis* takes the form of partly concrescent legumes grouped round a center, while in *N. damascene* (love-in-a-mist) they appear fully fused.

#79

Nature hides the leafy character from our sight most effectually when she forms sappy and soft, or woody and tough seed-cases; but she will not be able to escape our scrutiny when we know how to follow her carefully in all transitional phases. Here it may be enough to have indicated the general conception involved, and to have referred to some examples showing nature's accordance with it. The extreme multifariousness of seed-vessels gives us material for further consideration in the future.

#80

The relationship of the seed-vessels to the preceding members shows itself also in the stigma, which in many cases is sessile and inseparably bound up with the seed-vessel. We have already indicated the affinity of the stigma with leaf form, and we may here refer to it once again; for in double poppies it may be noticed that the stigmas of the seed-capsule are transformed into delicate little colored leaves, completely resembling petals.

#81

The last and most important expansion which the plant exhibits in its growth, shows itself in the fruit. Both in inner energy and in outer form this expansion is often very great, indeed enormous. Since the enlargement generally occurs after fertilization, it appears that the seed, having entered upon its definitive development, since it draws upon the juices of the whole plant for its growth, gives them a trend towards the seed-case. With the help of these juices the vessels become nourished, dilated, and often in the highest degree filled and expanded. From the foregoing argument it may be concluded that the purer kinds of gas take a great share in this process; this idea is confirmed by the experimental fact that the distended legumes of *Colutea* (bladder senna) contain pure air.

XI. CONCERNING THE IMMEDIATE ENVELOPES OF THE SEED

#82

In contrast to the expansion of the fruit, we find that the seed shows the extreme degree of contraction, while its interior is highly elaborated. It may be noticed in various cases that the seed transforms leaves into its immediate integuments, and that it adjusts them more or less to itself -- generally, indeed, by its own energy moulding them closely to itself and quite altering their form. Since we have already seen many seeds developed from a single leaf, and enclosed therein, we need not be surprised that an individual seed-embryo should clothe itself in a leafy integument.

#83

In many winged seeds we can detect indications of the leafy seed-coat not being perfectly fitted to the seed -- for example, in the maple, the elm, the ash, and the birch. A very remarkable example of how the seed-embryo

gradually draws together more expanded sheaths and adjusts them to itself, is offered to us by the three differing zones of heterogeneously formed seeds in the marigold. The outermost circle still preserves a shape akin to that of the leaves of the calyx, except that a seed-rudiment, straining the midrib, induces a curvature of the leaf, and the concavity is divided lengthways into two parts by a membrane. The succeeding circle has suffered further change, the wings of the little leaf, and the membrane, having quite disappeared. The form, on the other hand, is somewhat less elongated, and the seed-rudiment at the back shows itself more distinctly, while the little protuberances, which it bears, are more conspicuous. These two series appear to be either not at all, or only imperfectly, fertile. To these succeeds the third series; it has the authentic, strongly curved form, with a completely fitting coat, fully developed in all its variegation of ridges and excrescences. Once more we see here a vigorous contraction of an expanded leaf-like member, induced through the inner activity of the seed, just as we previously saw the petal contracted through the influence of the anther.

XII. RECAPITULATION AND TRANSITION

#84

And thus we have followed in the steps of nature as scrupulously as we may; we have accompanied the outward form of the plant in all its transformations, from its development out of the seed, until the seed arose again; and without pretending to disclose the first springs of nature's action, we have directed our attention to the manifestation of the forces whereby the plant gradually transforms one and the same organ. In order not to lose hold of the thread which we have once grasped, we have throughout considered the plant only as an annual, and we have noticed only the transformations of the leaves associated with the nodes, and have derived all forms from them. But, in order to give this essay the necessary completeness, we must now speak of the *buds* which lie concealed beneath each leaf, and develop under certain conditions, while, under other circumstances, they apparently disappear entirely.

XIII. CONCERNING THE BUDS AND THEIR DEVELOPMENT

#85

Nature bestows on each node the power to produce one or more buds. This happens in the neighborhood of the leaves investing it, which appear to prepare for the formation and growth of the buds, and to cooperate in these processes.

#86

Upon the successive development of one node from another, and the formation of a leaf at each node with a bud in its neighborhood, depends the first simple, gradually progressive reproduction of vegetables.

#87

It is well known that the activity of such a bud has a great similarity to that of the ripe seed; and that often in the bud, still more than in the seed, the whole form of the future plant may be recognized.

#88

Although a point from which a root will originate cannot be observed in the bud with equal facility, still it is really present there, as in the seed, and develops rapidly and easily, especially under moist conditions.

#89

The bud needs no cotyledons, since it is in connection with its mother plant, which is already fully organized, and out of which, so long as it is in union with it, it obtains sufficient nourishment. If the bud is separated from its parent, it draws its supplies from the new plant on which it is grafted, or if, as a branch, it is planted in the earth, through the roots which are promptly produced.

#90

The bud consists of nodes and leaves, more or less developed, which are able to carry the future growth further. The lateral branches, which spring from the nodes of plants, may be regarded, then, as individual plantlets which take their stand upon the body of the mother, just as the latter is fixed in the earth.

#91

The seed and the lateral branch have frequently been compared and contrasted, and especially with so much insight and accuracy not long ago, that we may content ourselves with referring to this work with unconditional assent.[136]

#92

We will cite only this much: that, in highly organized plants, nature distinguishes buds and seeds clearly from one another, but, if we descend to the less complex, the distinction between the two seems to vanish, even to the sight of the keenest investigator. There are indubitable seeds and indubitable gemmae; but the point at which the truly fertilized seeds (isolated from the mother-plant by the operation of the two sexes) coincide with the gemmae (which are directly derived from the plant and detach themselves with no obvious cause) may indeed be apprehended by the intellect, but in no way by the senses.

#93

This being well pondered, we may venture to infer that the seeds--which are distinguished from the buds by their enclosed condition, and from the gemmae by the evident cause of their formation and detachment--nevertheless are closely related to both.

XIV. FORMATION OF COMPOUND FLOWERS AND FRUITS

#94

We have hitherto sought to explain simple flowers, as likewise seeds which are enclosed in seed-vessels, through the transformation of nodal leaves. It will be found on closer investigation that in this case no buds develop -- indeed the possibility of such a development is completely annulled. But in order to interpret both compound flowers and collective fruits borne around a single cone, a single spindle, a single disc, and so forth, we must call to our aid the development of buds.

#95

We frequently notice that stems, without preparing for some time, and holding themselves in reserve for a single flower, produce their flowers nodally, and often proceed thus continuously to their apex. But the phenomena thus displayed may be explained on the theory proposed above. All the flowers which develop from lateral buds are to be regarded as entire plants, which are set in the mother plant, as the mother plant is set in the earth. Since, under these circumstances, they receive purer saps from the nodes, so even the earliest leaves of the branchlets are indeed much more

highly perfected than the first leaves of the mother plant which succeed the cotyledons; so much so that the formation of calyx and flower is often immediately possible.

#96

The same flowers, which are developed from lateral buds, would with increased nutrition have become branches, and would have experienced, in like manner, the fate to which the mother-stem, being in the same case, is obliged to submit.

#97

As now from node to node flowers of a similar kind develop, so we notice the same changes of the stem leaves as we observe above in the gradual transition to the calyx. These stem leaves gradually contract more and more, and finally dwindle almost completely. Since they then diverge more or less from leaf form, they are given the name of bracts. Correspondingly the stem becomes more slender, the nodes become more closely set, and all appearances noticed above may be again traced here, except that no sharply defined inflorescence follows at the end of the stem, since nature has exercised her right already from bud to bud.

#98

As we have now fully considered a stem adorned with a flower at each node, we shall be able to interpret a *collective inflorescence* quite easily, provided we call to our aid what has been said above about the origin of the calyx.

#99

Nature forms a common *calyx* from *many leaves* which she crowds upon one another and collects around an axis. With the same strong growth impetus she modifies *an elongated stem*, as it were, in such a way that *all its buds are produced at once in the guise of flowers, thronged together in the closest possible proximity*; each floret fertilizes the seed-vessel already prepared below it. In this monstrous crowding, the nodal leaves do not invariably disappear; in the thistles the bract faithfully accompanies the floret, which develops from its associated bud. To illustrate this paragraph, the structure of the teasle (*Dipsacus laciniatus* L.) should be examined. In many grasses, each flower is accompanied by such a bract, which in this case is called the glume.

#100

In this way it will become apparent to us how it is that *the seeds developed by a composite flower are genuine buds, perfected and elaborated through the operation of the two sexes.* If we hold fast to this conception, and consider in this sense the growth and fructification of various plants, personal observation of a comparative kind will best convince us.

#101

It will then indeed not be difficult for us to explain the fructification of enclosed or exposed seeds, often collected round an axis, in the middle of a single flower. For it is all the same whether a single flower surrounds a complex fructification -- the concrescent pistils absorbing the generative saps from the anthers of the flower and imbuing the seed with them -- or whether each seed possesses its own pistil, its anthers, and its own corolla.

#102

We are convinced that with some practice there is no difficulty in explaining the multifarious forms of flowers and fruits in this way. It will admittedly be necessary for this purpose to operate with the conceptions of expansion and contraction, of compression and anastomosis, established above, as easily as with algebraic formulae, and to know how to use them in the right places. Now much depends upon the accurate observation and comparison with one another of the various stages which nature follows, as well in the formation of genera, species, and varieties, as in the growth of a single plant; hence a collection of illustrations arranged in order for this end, and an application of the botanical terminology of the various plant members, purely from this point of view, would be desirable, and certainly would not be without use. Two examples of proliferated flowers, giving strong support to the theories adduced, will, if demonstrated to the eye, afford crucial instances.

XV. PROLIFERATED ROSE

#103

All that we have hitherto sought to comprehend with the power of the imagination and intellect alone, is revealed with the greatest clearness in the example of a proliferated rose. Calyx and corolla are arranged and

developed round the axis, but there is no *growth-inhibited*[137] seed receptacle in the center, with the male and female reproductive organs *placed in orderly sequence* on it and around it; instead of this, the stalk, half *reddish* and half *greenish*, *elongates* again, while smaller petals develop upon it *in succession*. These are dark red and folded on themselves, and some of them bear traces of anthers. The stem goes on growing, and prickles are seen on it again. The colored petals which follow are spaced apart; they become smaller and merge before our eyes into partly red and partly green stem leaves. A succession of regular nodes is formed, from the buds of which arise little rosebuds, which are, however, imperfect.

#104

This example gives us thus a visible proof of the considerations previously advanced; namely that all calyces are floral leaves, only united by their margins. For here the calyx, regularly arranged round the axis, consists of five completely developed compound leaves of three or five leaflets, just like those that are borne by the branches of roses at their nodes.

XVI. PROLIFERATED PINK

#105

After we have studied this phenomenon carefully, another, which is to be observed in a proliferated pink, will seem to us almost more remarkable. We see a complete flower, the calyx of which has a double corolla above it, terminating in the midst with a seed-capsule, which is, however, imperfect. From the sides of the corolla, four complete new flowers develop, separated from the mother-flower by means of three or more nodes; like the mother-flower, they have calyces, and are doubled, but not so much by means of individual petals as, either by means of corollas, the claws of which are concrescent, or, more usually, by means of petals, which are united in branchlet form, and clustered round a stalk. Notwithstanding this monstrous development, the filaments and anthers are present in some. The seed-vessels with styles are to be seen, and the placental region[138] has again grown out into leaves. In one of these flowers the seed-envelopes[139] were associated into a complete calyx, containing, in its turn, the rudiment of a complete double flower.

#106

We have in the rose a flower, as it were, half perfected, out of the center of which a stem again shoots forth, bearing on itself new stem leaves. So we find in this pink that -- in addition to a normally formed calyx, a complete corolla, and *a pistil in the very center --buds develop from the region of the petals*, and display actual branches and flowers. Both cases then show us that nature, in the ordinary course, carries growth to a conclusion in the flower, and, as it were, sums it up, so that -- in order the more quickly to reach the goal through the formation of seeds -- she puts a stop to the possibility of an indefinite and gradual progression.

XVII. LINNAEUS' THEORY OF ANTICIPATION

#107

If I have stumbled here and there on this road, which one of my predecessors, who sought it moreover under the guidance of his great teacher, describes as full of terrors and perils[140]; if I have not levelled it sufficiently; nor succeeded in sweeping away all obstacles for my successors: I still hope not to have undertaken this labor fruitlessly.

#108

It is now time to take into consideration the theory which Linnaeus proposed for the interpretation of these very phenomena. The observations which prompted the present essay could not elude his keen glance. And if we are able to pass beyond the point at which he halted, we owe it to the common efforts of so many observers and thinkers, who have cleared away various impediments and have dissipated many prejudices. An exact comparison of his theory and that set forth above, would delay us too long. Experts will easily make the comparison for themselves,and to render it clear to those who have not previously attended to the subject, would involve too much detail. We will only indicate shortly what it was that prevented Linnaeus from progressing further and reaching a goal.

#109

He made his observations especially on trees -- those complex and long-lived plants. He noticed that a tree in a large pot, supplied with

excessive nourishment, produced branch after branch for several years in succession, while the same tree, cultivated in a smaller pot, rapidly brought forth flowers and fruit. He saw that the successional development in the former, suddenly became telescoped in the latter. Hence he called this process of nature *Prolepsis*, and *Anticipation*, since the plant seemed to forestall six years in passing through the six steps to which we have alluded above. And so he worked out his theory in relation to the buds of trees, without paying any special regard to annual plants, since he must indeed have observed that to them it was less applicable. For according to his doctrine one needs to suppose that each annual plant must, intrinsically, have been destined by nature to grow for six years, and that it all at once anticipates this long period of time in reaching the stage of flower and fruit, and thereupon dies.

#110

We, on the contrary, have first followed the growth of the annual plant; starting from this point, the application of the argument to perennial plants is easily made, since a bud shooting forth from the oldest tree is to be regarded as an annual plant, even if it develops directly out of a long-existent stem, and may itself be destined to a prolonged life.

#111

The second cause which hindered Linnaeus from advancing further, was that he visualized the various concentric zones of the plant body -- the outer and the inner cortex,[141] the wood, and the pith -- too much as parts which acted equally, and were in an equal degree living and essential; and he ascribed the origin of the flower-and fruit-members to these various zones of the stem, since these members, as well as the stem-zones, appear to enclose one another and to develop out of one another; but this was only a superficial observation, which will not endure closer scrutiny. For the outer cortex is not fitted for further development, and in long-lived trees it becomes, towards the outside, an indurated and isolated mass, as the wood becomes hardened towards the center. In many trees the outer cortex is shed, and in others it may be removed without injuring them in the least. It cannot therefore bring forth either a calyx or any other living part of the plant. It is the second cortex[142] which possesses all the capacity for life and growth. If it is partially

destroyed, to that degree growth is interrupted; it is the second cortex which, on careful consideration, we find produces all the exterior parts of the plant, either gradually in the stem, or all at once in the flowers and fruit. But only the subordinate function of producing the petals was ascribed to it by Linnaeus. The important production of the male staminal apparatus fell, on the other hand, to the wood; but it may easily be observed, on the contrary, that the wood itself is brought to a state of repose by its solidification, and durable as it is, it is incapable of performing vital operations. The pith, finally, is supposed to accomplish the principal function, that of producing the female reproductive organs and a numerous progeny. The doubt which has been cast upon the great importance of pith, and the reasons upon which this doubt is grounded, are to me weighty and decisive. The style and fruit present merely a superficial appearance of originating from the pith, because these structures, when they first make their appearance, are in a soft, ill-defined, pith-like, parenchymatous condition, and are crowded together just in the center of the stem, where we are accustomed to see only the pith.

XVIII. SUMMARY

#112

I hope that the present attempt to interpret the metamorphosis of plants may contribute something to the solution of this enigma, and may give occasion for additional investigations and deductions. The scattered observations on which it is based have already been collected and arranged in order;[143] and it will soon be decided whether the step which we have here taken constitutes an approach to the truth. We will now as shortly as possible, summarize the principle of the foregoing discourse.

#113

If we consider a plant insofar as it expresses its life force, we see that this force reveals itself in two directions -- first, in *vegetative growth*, when it produces stem and leaves, and then in *reproduction*, which is completed in flower-and fruit-formation. If we inspect growth more closely, we see that, since the plant carries forward its existence from node to node and from leaf to leaf as it vegetates, a reproduction may be said to take place. This type of generation distinguishes itself, by the fact that it is *successive*, from the

reproduction through the flower and fruit, which happens *suddenly*; being successive, it shows itself in a sequence of individual developments. The vegetative force, gradually expressing itself, bears an extremely close relation[144] to that which manifests itself once and for all in a conspicuous reproductive phase. A plant can be compelled, under various conditions, to *vegetate continuously*, while, on the other hand, one can *hasten the flowering phase*. The former result occurs when crude saps flood the plant; the latter when more rarefied forces predominate.

#114

When in this way we have named the *vegetative shoots* as representing successive reproduction, and *flower and fructification* as representing simultaneous reproduction, we have, in so doing, indicated the manner in which they both express themselves. A plant which *vegetates*, spreads itself more or less, and develops a stalk of stem; the intervals from node to node are generally noticeable; and its leaves spread out from the stem on all sides. On the other hand, a plant which *flowers* has contracted all its parts; increase in height and breadth is, as it were, arrested; and all its organs are in a highly condensed state and developed in close proximity to one another.

#115

When now the plant vegetates, blooms, or fructifies, so it is still the *same organs* which, with different destinies and under protean shapes, fulfill the part prescribed by nature. The same organ which on the stem expands itself as a leaf, and assumes a great variety of forms, then contracts in the calyx -- expands again in the corolla -- contracts in the reproductive organs -- and for the last time expands as the fruit.

#116

This operation of nature is at the same time bound up with another -- the *assembling of different organs around a center*, according to definite numbers and proportions, which, however, in many flowers may often be, under certain circumstances, much modified and variously changed.

#117

In like manner in the *formation* of flowers and fruit an *anastomosis* operates, whereby the extremely delicate fructification parts, closely crowded

against one another, are most intimately united, either throughout their whole duration, or only for part of this time.

#118

These phenomena of *approximation*, *arrangement around a center*,[145] and *anastomosis*, are not, however, peculiar to flowers and fructifications. We may, indeed, perceive something similar in cotyledons; and other plants members will give us ample material for similar considerations in the sequel.

#119

Just as we have now sought to explain the protean organs of the vegetating and flowering plant all from a single organ, *the leaf*, which commonly unfolds itself at each node; so we have also attempted to refer to leaf-form those fruits which closely cover their seeds.

#120[146]

It goes without saying that we must have a general term to indicate this variously metamorphosed organ, and to use in comparing the manifestations of its form; we have hence adopted the word *leaf*. But, when we use this term, it must be with the reservation that we accustom ourselves to relate the phenomena to one another *in both directions*. For we can just as well say of a petal that it is a stamen in a state of expansion. And we can just as well say that a sepal is a contracted stem leaf, approaching a certain degree of refinement, as that a stem leaf is a sepal, expanded through the intrusion of cruder saps.

#121

In the same way it may be said of the stem[147] that it is an expanded flowering and fruiting phase, just as we have predicated of the latter that it is a contracted stem.

#122

I have moreover at the conclusion of this essay considered the development of the *buds*, and through them have sought to explain compound flowers and unenclosed fruits.

#123

And in this way I have labored to expound, as clearly and completely as I could, an idea which in my eyes has much that is convincing. If, in spite of all, it is still not fully in accordance with the evidence; if fault may still be

found with it for some inconsistencies; and if the foregoing manner of interpretation does not seem to be universally applicable: so much the more will it be my duty to note all objections, and to treat this subject more exactly and circumstantially in the sequel, in order to make this way of looking at things more lucid, and to earn for it a more general approval than it can perhaps expect today.

Endnotes

1 Throughout this Introduction the references to Goethe's writings are given either from Goethe, J. W. von (1887 etc.): *Werke herausgegeben im Auftrage der Grosshersogin Sophie von Sachsen, Weimar* (cited here as Sophien-Ausgabe), or from troll, w. (1926): *Goethes Morphologischen Schriften*, Jena (cited here as Troll, ed.; when, however, the reference is not to Goethe's writings, but to Troll's own introductory matter, the book is cited as Troll, W. (1926)); or from the German part of Goethe, J. W. von (1831): *Versuch ueber die Metamorphose der Pflanzen. Uebersetzt von F. Soret, nebst geschichtlichen Nachtraegen*. Stuttgart (cited here as Soret, ed.).

2 The references to the literature in the present Introduction have been limited by the inaccessibility of modern German work under the present conditions; I have not, for instance, been able to see Schmidt, G. (1940): *Goethe und die Naturwissenschäften*, pp. 618, Halle. To this bibliographical work, and to other titles, Dr. Verdoorn has kindly called my attention.

3 Robertson, J. G. (1932): *The Life and Work of Goethe. 1749-1832.* London, pp. 312 & 97.

4 Sherrington, C. (1942): *Goethe on Nature and Science.* Cambridge, England; p. 23.

5 Troll, W. (1926): l.c., p. 5.

6 Sherrington, C. (1942): l.c., p. 21.

7 Troll, W. (1926): l.c., p. 7.

8 Soret, ed.: *Nachtraege und Zusaetze*, I. *Der Verfasser theilt die Geschichte seiner botanischen Studien mit*. Pp. 107-63 (German & French version). Our knowledge of Goethe's botanical history is largely derived from this piece of autobiography, which is to be found also in Troll ed., pp. 187-209.

9 Bischoff, C. (1931): *The Hard Road: The Life Story of Amalie Dietrich*. Translated by A. Liddell Geddie. London. (C. Bischoff is the great-great-grand-daughter of Adam Dietrich, on whom *see* Benedikt, E. (1945): *Goethe und Linne*. Svenska Linne-Saellskapets Arsskrift, 28, pp. 49-54; this paper appeared after the present Introduction was in print.

10 The title is Gesner (Gessner), J. (1743): *Dissertationes physicae de vegetabilibus. Quarum prior partium vegetationis structuram, differentias et usus, posterior vero partium fructificationis structuram differentias, ac usus sistit. In quibus elementa botanica Celeb. Linnaei dilucide explicantur.* (Printed with Linnaeus, C. (1743): *Oratio de necessitate peregrinationum intra patriam*. Lugduni Batavorum).

11 See p. 76.

12 *Goethes Briefe*. Sophien-Ausgabe, Abth. IV, Bd. 27, p. 219.

13 *Goethes Briefe,* l.c., p. 200, Oct. 14, 1816.

14 For an account of Batsch, and his relations with Goethe, see Hansen, A. (1907): *Goethes Metamorphose der Pflanzen*. (2 pts. Text and Plates). Giessen. Chapter VII.

15 Batsch, A. J. G. C. (1787): *Versuch einer Anleitung zur Kenntnis und Geschichte der Pflanzen*. Halle; see p. 8.

16 *Probleme*, Troll ed., p. 221.

17 *Entstehen des Aufsatzes uber Metamorphose der Pflanzen*. Troll ed., p. 208.

18 *Probleme*, Troll ed., p. 221.

19 Hedwig, J. (1781): *Vom waren Ursprunge der männlichen Begattungswerkzeuge der Pflanzen*. Leipziger Mag. zur Naturkunde, Math. und Oecon. (Leipzig und Dessau), pt. III, pp. 257-319; see p. 299.

20 Information by letter from Professor G. Gola, Sept. 14, 1945.

21 Troll, W. (1926): l.c., p. 52.

22 Throughout this Introduction, this work, of which a translation follows (pp. 88-115), will be cited as *Metamorphose*.

23 Theophrastus (1916): *Enquiry into Plants*. Translated by Sir A. Hort, London. I.xiii.2; vol. I, p. 90.

24 Grew, N. (1672): *The Anatomy of Vegetables Begun*. London; see pp. 129-32, etc., discussed in Arber, A. (1942): *Nehemiah Grew (1641-1712) and Marcello Malpighi (1628-1694)*. Isis, vol. 34, pp. 7-16; *see* p.12.

25 Malpighi, M. (1675): *Anatome Plantarum*. London; p. 46 and pl. 28, fig. 160, "mixtura staminis et folii."

26 For details of Wolff's career, and critical appreciation of his work, see Kirchhoff, A. (1867): *Die Idee der Pflanzen-Metamorphose bei Wolff und bei Goethe*. Berlin.

27 Wolff, C. F. (1768): *De formatione intestinorum*. Novi Commentarii Acad. Scientarum Imperialis Petropolitanae, vol. 12, pp. 403-507; see pp. 404-406.

28 *Meteore des literarischen Himmels. Plagiat*. Sophien-Ausgabe, Abt. II, Bd. 11, p. 252.

29 For a detailed review of the history and influence of Goethe's ideas, see Wigand, A. (1846): *Kritik und Geschichte der Lehre von der Metamorphose der Pflanze*. Leipzig. In reading this book, allowance must be made for its date, and for the fact that Wigand's turn of mind was laborious rather than illuminating. Some criticisms of Wigand's work will be found in Kirchhoff, A. (1867): l.c.

30 Butler, E. M. (1935): *The Tyranny of Greece over Germany*. Cambridge, England; p. 113.

31 *Schicksal der Handschrift*. Troll ed., pp. 211-12.

32 On the editions see Hansen, A. (1907): l.c., p. IX. Those who wish for a modern reprint will find the one in Troll ed. valuable, as it is beautifully illustrated with early, and also with new, figures.

33 Martins, C. F. (1837): *Oeuvres d'histoire naturelle de Goethe, traduits et annotés par Ch. Fr. Martins avec un atlas in-folio contenant les planches originales de l'auteur, et enrichi de trois dessins et d'un texte explicatif sur la métamorphose des plantes par P. J. F. Turpin. Paris. Destinée de l'opuscule imprimé*, p. 267. This discourse, which Goethe called *Schicksal der Druckschrift*, took more than one form, and I have not found the passage cited except in Martin's translation.

34 Linnaeus, C. (1767): *Systema Naturae*. Vol. 2, Editio Duodecima, Reformata. Holmiae; p. 8.

35 Jaeger, G. F. von 1814): *Ueber die Missbildungen der Gewächse*. Stuttgart; p. 252.

36 *Metamorphose*, § 119.

37 Naegeli, C. von (1884): *Mechanisch-physiologische Theorie der Abstammungslehre*. München und Leipzig.

38 Cf. Kirchhoff, A. (1867): l.c., pp. 28 and 31.

39 Lakon, G. (1921): *Goethes physiologische Erklärung der Pflanzenmetamorphose als moderne Hypothese von dem Einfluss der Ernährung auf Entwicklund und Gestaltung der Pflanze*. Beihefte zum Bot. Centralbl., Bd. 38, Abt. I, pp. 158-81.

40 Hayata, B. (1921): *An Interpretation of Goethe's Blatt*. Icon. Plant. Formos. X, pp. 75-95. I know only the referat in Bot. Jahrb., vol. 57, 1922, Literaturbericht, pp. 47-8.

41 *Metamorphose*, § 73.

42 Hedwig, J. (1781): l.c., p. 308.

43 *Metamorphose*, § 60.

44 Sophien-Ausgabe, Abt. II, Bd. 7, pp. 37-68. French translation in Martins, C. F. (1837): l.c., pp. 329-33.

45 Linnaeus, D. (1767): l.c., p. 8; see also Ullmark, H. (1760): *Prolepsis planatrum*, in Linnaeus, C. 91764): *Amoenitates Academicae*. Lugduni Batavorum. vol. 6, No. cxviii, pp. 324-41.

46 For Goethe's attitude to preformation see *Der Inhalt bevorwortet*, p. 120, in *Zur Morphologie*, Troll ed.

47 *Metamorphose*, § 111.

48 *Metamorphose*, § 6.

49 *Metamorphose*, § 17.

50 Quoted in Troll, W. (1926): l.c., p. 52.

51 Sophien-Ausgabe. Abt. ii, Bd. 6, *Zur morphologie. Verfolg*, p. 331, *Unbillige Förderung*, 1824.

52 Turpin, P. J. F. (1837): *Esquisse d'organographie végétale, ...pour servir à prouver...la métamorphose des plantes de Goethe*. Paris et Genève; see p. 7.

53 Troll ed.: *Der Verfasser teilt die Geschichte seiner botanischen Studien mit*. p. 197.

54 Troll, W. (1926): l.c., p. 8. See also Saunders, [T.] Bailey (1893): *The Maxims and Reflections of Goethe*. London. No. 577, p. 200.

55 Candolle, C. de (1868): *Théorie de la Feuille*. Arch. Sci. phys. nat., Genève. vol. 32, pp. 31-64.

56 Arber, A. (1941): *The Interpretation of Leaf and Root in the Angiosperms*. Biol. Rev., Cambridge, England, vol. 16, pp. 81-105. This paper includes a fuller account of the partial-shoot theory, and the evidence on which it is based, than can be given here.

57 See preceding footnote.

58 Troll, W. (1938): *Vergleichende Morphologie der höheren Pflanzen*. Berlin, Bd. 1, Teil 2, p. 957.

59 Quoted in Troll, W. (1926): l.c., p. 52.

60 Sophien-Ausgabe, Abth. II, Bd. 13 (Nachträge zu Bd. 6-12), Nachträge zu Bd. 7. Paralipomena 130, p. 125.

61 Geoffroy Saint-Hilaire (Étienne) (1831): *Sur des Écrits de Goethe lui donnant des droits au titre de savant naturaliste*. Ann. d. Sci. nat., T. 22, pp. 188-93; see p. 190.

62 See especially the Sophien-Ausgabe, and Troll ed.

63 Troll ed. *Nacharbeiten und Sammlungen*, p. 239.

64 Schuster, J. (1924): *Goethe, die Metamorphose der Pflanzen mit dem Originalbildwerk*. Berlin; pp. 116, 118, 121.

65 Hansen, A. (1907): l.c.

66 Schuster, J. (1924): l.c.

67 Schuster, J. (1924): l.c., pl. VII.

68 Sophien-Ausgabe, Abth. II, Bd. 13 (Nachträge zu Bd. 6-12), Nachträge zu Bd. 7. Paralipomena 137, p. 132.

69 Schuster, J. (1924): l.c., Fig. 2, p. 79.

70 Sophien-Ausgabe, Bd. 32. *Italiänische Reise. III. Zweiter Römische Aufenthalt. Störende Naturbetrachtungen*. p. 47 (July 1787).

71 Sophien-Ausgabe, Bd. 32, *Lesarten* (June and July 1787), p. 389.

72 On this question see pp. 119-20.

73 Letter to Kanzler F. T. A. H. von Mueller, May 24, 1828, Troll ed., p. 447.

74 Note appended to a letter to Nees von Esenbeck, April 2, 1818. *Goethes Briefe*. Sophien-Ausgabe, Bd. 44, p. 54.

75 See especially an interesting study of J. B. Robinet and the type concept in Lovejoy, A. O. (1936): *The Great Chain of Being*. Harvard University Press; pp. 269-83.

76 On this point see Hansen, A. (1919): *Goethes Morphologie*. Giessen; p. 26.

77 *Vorarbeiten zu einer Physiologie der Pflanzen. Einleitung*. Sophien-Ausgabe, Abth. II, Bd. 6, Theil I, pp. 312-13.

78 *Nacharbeiten und Sammlungen*. Troll ed., p. 251.

79 Curtis, J. T. (1941): *Peloric Flowers in Cypripedium reginae Walt*. Amer. Midland Nat., vol. 25, pp. 580-83.

80 It seems scarcely possible to accept Sherrington's suggestion that Goethe's views were akin to those of Lamarck; l.c., p. 20.

81 See, for example, Sherrington, C. (1942): l.c., p. 22.

82 Goethe speaks, for instance, of the type animal (Urtier) as "den Begriff, die Idee des Tieres"; see *Der Inhalt bevorwortet*, in *Zur Morphologie*, Troll ed., p. 122.

83 Hansen, A. (1907):L l.c., p. 91.

84 *Versuch aus der vergleichenden Knochenlehre*. (1784). Troll ed., p. 380.

85 On the replacement of the type concept by that of parallelism, cf. Arber, A. (1937): *The Interpretation of the Flower: a study of some aspects of morphological thought*. Biol. Rev. (Cambridge, England), vol. 12, pp. 157-84; see pp. 173, etc.

86 Sherrington, C. (1942): l.c., pp. 21-22.

87 *Versuch aus der vergleichenden Knochenlehre, dass der Zwischenknochen der obern Kinnlade dem Menschen mit den übrigen Tieren gemein sei.* (1784) Troll ed. p. 363, et seq.

88 Trevelyan, H. (1941): *Goethe and the Greeks.* Cambridge, England. See Chap. IV, especially pp. 159-78.

89 Uhde, H. (1877): *Goethe Briefe an Soret.* Stuttgart. Letter to Soret dated August 3, 1828, pp. 56, 57. Also Sophien-Ausgabe, Abt. II, Bd. 13 (Nachträge zu Bd. 6-12), Nachträge zu Bd. 6, paralipomena 70, p. 63.

90 Uhde, H. (1877): l.c. Letters to Soret, July 14, 1828, p. 51, and June 28, 1828, p. 43.

91 Candolle, A. P. de (1862): *Mémoires et Souvenirs.* Genève et Paris; p. 573.

92 See p. 86.

93 Candolle, A. P. de (1827): *Organographie végétale*, Paris, vol. 2, p. 240.

94 Candolle, A. P. de (1827): l.c., vol. 1, pp. 139-40.

95 See Schuster, J. (1924): l.c., pp. 107-108.

96 *Schicksal der Druckschrift.* Troll ed., p. 215.

97 *Die Absicht eingeleitet*, in *Zur Morphologie.* Troll ed., pp. 114-15.

98 *Briefwechsel zwischen Schiller und Goethe.* Theil I, 1794 und 1795. Stuttgart und Tübingen, 1828, pp. 13-14.

99 "das Ganze im kleinsten erblicken." Quoted in Troll, W. (1926): l.c., p. 36.

100 *Wilhelm Meister's Lehrjahre.* Sophien-Ausgabe, Bd. 23, pp. 309-10.

101 Troll, W. (1926): l.c., p. 97, et seq.

102 *Betrachtung über Morphologie überhaupt.* Troll ed., p. 229.

103 Troll, W. (1925): *Gestalt und Gesetz.* Flora, N. F. Bd. 18 and 19 (G. R. Bd. 118 and 119), Goebel Festschrift, pp. 536-65; see p. 556.

104 Saunder, [T.] Bailey (1893): l.c., No. 394, p. 146.

105 *Wirkung meiner Schrift.* Troll ed., p. 259; for Goethe's views on teleology, see Eckermann, J. P. (1836): *Gespräche mit Goethe in den letzten Jahren seines Lebens. 1823-1832.* Theil II. Leipzig; p. 282; and *Conversations of Goethe with Eckermann and Soret* (1850): Translated by J. Oxenford. London; vol. 2, p. 347.

106 Troll, W. (1925): l.c.

107 *Betrachtung über Morphologie überhaupt.* Troll ed., p. 228.

108 On this subject see Troll, W. (1926): l.c., p. 78, etc., and Hansen, A. (1907): l.c., pp. 277-78.

109 For an interesting and clear account of Goethe's *Farbenlehre*, see Sherrington, C. (1942): l.c., pp. 8-18.

110 Croce, B. (1923): *Goethe*. Translated by E. Anderson, with an introduction by D. Ainslie. London; p. 14.

111 *Einwirkung der neueren Philosophie*. Troll ed., p. 285.

112 *Schillers Briefwechsel mit Koener* (1847): Theil II. Berlin. Letter of Nov. 1, 1790, p. 207.

113 *The Centenary of Goethe*. Times Literary Supplement. London. March 24, 1932, p. 210.

114 *Essai sur la Métamorphose des Plantes, Traduit de l'Allemand sur l'Édition originale de Gotha* (1790) par m. Frédéric de Gingins-Lassaraz. Genève, 1829.

115 Schuster, J. (1924): l.c., p. 110, footnote 3.

116 For the German title see citation in footnote 1, p. 67.

116 Uhde, H. (1877): l.c., p. 93.

117 *Conversations of Goethe with Eckermann and Soret* (1850): l.c., vol. 2, p. 374; Eckermann, J. P. (1836): l.c., p. 317.

118 See Soret's translation, p.225.

119 Title cited on p. 74.

120 This is the translation of the citation as given by Goethe; the full reference is Ullmark, H. (1764): *Prolepsis plantarum*. In Linnaeus, C., *Amoenitates Academicae*, Lugdouni Batavorum. Vol. 6, No. cxviii, p. 341. (Hereafter cited as A.A.)

121 Soret ed., p. 9. translates this incorrectly as "aussi épais que longs." (A.A.)

122 Goethe uses *Gefässe* as a vague general term for anatomical elements forming the leaf (cf. also #25). See Sachs, J. von (1890): *History of Botany*. Trans. by Garnsey, H. E. F. and Balfour, I. B., Oxford, p. 254, for the indefinite use of the word vessel in the eighteenth century. (A.A.)

123 In a letter to Soret, July 14, 1828 (Uhde, H. (1877): l.c., p. 51) Goethe says that he used *Agrumen* (the word employed in #22.) for "die ganze Sippschaft der Citronen, Pommeranzen u.s.w." (A.A.)

124 See note to #18. (A.A.)

125 Goethe uses the name *Ranunculus aquaticus*. (A.A.)

126 The expression "Hölungen der Rohre" used here is translated "cavités des joncs" by Soret; "vaisseux" by Gingins-Lassararaz and Martins; and "hollow stems" by Cox. (A.A.)

127 Goethe's expression is "von Knoten zu Knoten geschlossen," but the examples he gives suggest that he actually meant "closed at the nodes." (A.A.)

128 Hedwig, Leikpziger Magazin, Part III. (For full reference see p. 71. (A.A.)

129 The word which I have translated "flowering phase" is "Blüthenstand"; Goethe uses this term indifferently for inflorescence and for flower. (A.A.)

130 This, which Goethe calls "Kelch," is now described as an involucre of bracts. (A.A.)

131 The Journal of Botany version (Cox) translates this as "pollen," which does not render Goethe's expression, "männlichen Samens" accurately. (A.A.)

132 Though the word "Kelchblätter" is here used, and is translated "feuilles du calice" by Soret, it seems to be an obvious slip for "Kronenblätter." (A.A.)

133 This translation though rather free, seems to convey the sense of "schwankende Bildungen." (A.A.)

134 On this case see Troll ed., p. 457. (A.A.)

135 Goethe uses the word "Pistill," but he is probably not including the ovarian region. (A.A.)

136 Gaetner, *De fructibus et seminibus planatarum*. Cap. I. [#92 also relates to this work by J. Gaertner. On gemmae *see* vol. I, Stuttgart, 1788, *introdctio generalis*, Cap. I, p. xi, etc. (A.A.)]

137 This expression is used for Goethe's "zusammengezogen." (A.A.)

138 This expression is used as a possible equivalent for Goethe's "Receptakel der Samen." (A.A.)

139 The word "Samendecken" used here is translated "arilles" by Soret. (A.A.)

140 Ferber *in* Praefatione Dissertationis Secundae de Prolepsi Plantarum. [The full reference is Ferber, J. J. (1763): *Prolepsis plantarum, in* Linnaeus, C., *Amoenitates Academicae*, Lugduni Batavorum, vol. 6, No. cxx, *Praefatio*, p. 365. (A.A.)

141 "Cortex" is used as a translation of "Rinde," but there is no exact English equivalent for this term, which, in Goethe's sense, includes epidermis, bark, cortex, phloem, and cambium. (A.A.)

142 Goethe no doubt included what we now call the cambium in "die zweyte Rinde." (A.A.)

143 Batsch, Anleitung zur Kenntniss und Geschichte der Pflanzen. Theil I, Cap. 19. [For fuller reference *see* p. 70.] (A.A.)

144 "Verwandt" misprinted "vewrandt" in the first issue of the first edition. (A.A.)

145 This expression is used for "Centralstellung", which is translated "concentrations" by Soret. (A.A.)

146 The translation here given for the early part of this paragraph is made somewhat freely, in order to convey the meaning, which cannot be understood without reference to the previous paragraph. (A.A.)

147 One is tempted here and elsewhere to translate "Stengel" as "vegetative shoot", but to do so would modernize Goethe's phraseology unduly. (A.A.)

TRANSLATOR'S ESSAY

Introduction

The biologists of the future will surely come to write critiques and appreciations concerned with Adolf Portmann's work and its contributions to the life-sciences. Since I am not a biologist by profession, I cannot write such a critique. However, my own discipline, philosophy, has enabled me to address the question of Portmann's contributions to the body of speculation found in the great tradition of the West's philosophical inquiries into living beings, a tradition which is very ancient and which goes back at least to the time of Hippocrates the so-called "Father of Medicine," -- and to Plato and Aristotle.

This present essay is, however, not intended as a contribution to what is usually known as "Philosophy of Science." That discipline, especially as it is most widely understood and practiced in England and America at the present time, is very largely concerned with contemporary *technologically* oriented science. As such, it does not address itself to the *theoretical* problems with which this present essay is concerned. Thus, since Portmann's purely scientific interests are essentially broader than those of technologically oriented science's, the usual scope of contemporary philosophy of science must be somewhat broadened in order to encompass Portmann's work.

An interpretive essay is, on those grounds, needed. What is more, his own view of science was in no sense of the term, *negative*: as he was so fond of pointing out, "Science should not be a negation!" Since much of our science is negative in its thrust -- that is, it sets out to disprove this or that commonly held idea about the world, and, what is yet more important, it views itself as a *replacement* of an earlier mode of thought -- we are likely to be puzzled if we are not forewarned. Very much of modern science is viewed as making its greatest contribution to the West precisely in so far as it replaces the sciences which preceded it; for many of us today, to embrace modern science and its methods is to reject what came earlier and, by the

same token, to reject that modern science and its methods is usually to reject it in favor of the old world view which modern science was, to a significant degree, designed to overthrow. Portmann, then, is liable to considerable misinterpretation because he avoids *either* posture to an amazing extent. Espousing, as he did, the methods and results of modern science -- of which he was a very distinguished representative -- when he thought they were successful and useful, he likewise worked very diligently to dissuade his scientific colleagues where he thought they were off-base or too narrow in their view. He was profoundly philosophic in his pursuit of knowledge and not, in the least, sectarian or prejudiced. This is, it seems to me, a primary reason why he is so very hard to follow at just those places where his colleagues became most partisan and doctrinaire. His work thus demands the most careful and, at the same time, placid, scrutiny possible by students of both philosophy and biology. In order to begin this scrutiny, we will touch upon several points of historical importance. The first of these concerns some of the details of the history of the concept of "the emergence of life," a concept which, by its very name, announces that the very *fact* of life is a problem for the science which uses the term.

The "Emergence" of Life

I once heard the philosopher, Hans Jonas, point out a very deep difference between pre-modern and modern thought: for pre-modern thought, *death* was the great puzzle of human existence; for us, today, *life* is the great puzzle. Jonas was correct in this. For, at an earlier time, life was a given, for all its darkness and obscurity. But it was not a surprise. In vivid contrast to this contemporary view, the non-living realm, which includes both dead things as well as things which never were alive, was almost always considered as having a vastly inferior status to the realm of living things. A very likely cause for this shift of perspective is the shift in science's view of the soul and its place in life-sciences, a shift which only began *after* what is generally agreed is the beginning of the scientific revolution.

By the time of Copernicus, Gilbert, Galileo, Kepler, and Descartes -- and thus by around 1630 -- the Christian West has had over a millennium and a half to get used to the idea which was implicit in the Christian teaching of

the conquest of death in the resurrection of the Son of the Creator of Heaven and Earth: the gulf separating life from death was not unbridgeable, and thus not as great as was once thought. Although several of the greatest founders of our modern, scientific, age had very serious reservations concerning the literal interpretation of scripture -- especially when that interpretation raised problems for the hypotheses of the new physics and astronomy -- this must not, in the least, be taken to mean that those great mathematical physicists and astronomers felt that the very *concepts* of life and soul, both also so central to Christian and Jewish thought, were in the least non-scientific, let alone *anti*-scientific. This was simply not the case. For example, William Gilbert, whose thinking is nowadays just beginning to re-emerge as one of the pillars of the new science, placed the concepts of life and soul at the very center of his 1600 work, *De Magnete*. Since that work is a model of experimental physics, (and even of theoretical cosmology), we might do well to glance at his work for a moment.

William Gilbert's book was read closely and admired greatly by scientific luminaries of the magnitude of Kepler, Galileo, and Descartes. In that book, Gilbert taught that the magnet was a *live* body with a *soul*. Magnetic phenomena were, one and all, taken to manifest what Gilbert refers to as the magnet's "formate soul." That is, the magnet's power comprised the activity of a physical body with a particular shape or form. Whereas we, today, say that all life-processes are reducible to pre-living, "physical," processes, Gilbert said that the soul of a magnet -- the source of its power both to approach or move away from another magnet, and to point "North" -- manifested nature's most simple and pure union of a dynamic soul with its physical body. The magnetic body has a certain inner structure or organization, and this, together with its outer shape, determines how its "magnetic soul" would act. *On the Magnet* presents us with a genuine biophysics or, as Gilbert himself called it, with a "Physiology."

Galileo read and vigorously approved of Gilbert's work. Whatever his final thoughts on the place of soul and life as constituents of the universe which he so brilliantly addressed as a mathematical physicist, neither he, Kepler, nor Descartes felt it necessary to root these out of the universe *before* they could address it as scientists.

Nearly a century after Gilbert, however, the great Newton absorbed the phenomena of magnetism, and with them, all the processes of life itself, into his general concept of a "force" which he defines as that "by which bodies are drawn, impelled, or in any way tend towards a point as to a center," (*Principia*, Definition V.) In doing this, the power of the formate souls of Gilbert's live magnetic bodies was trivialized into merely a sort of "gravity-like" force, and the stage was thereby set for the transformation of the life-sciences into what they tend to be today: the study of the way certain organized bodies exert force in order to preserve their vital systems intact in the face of other potentially destructive forces. "Life" has become "life-force", and, as Newton taught the world in his 1687 *Principia*, force is "an action exerted upon a body in order to change its state," (Definition IV). Gilbert, it should be remarked, quite carefully *denied* that the power which a magnet has was a force. So little is it a force that, according to the marvelous Dr. William Gilbert, M.D., the personal physician to Queen Elizabeth I -- herself the daughter of England's most famous tyrant -- any given magnet cannot magnetize any other piece of iron without making it a magnet as well. But this, for Gilbert, means that a magnet completely *shares* its magnetic potency at the instant it begins to polarize and magnetize the second piece of iron. For Gilbert, the power of magnets is not *at all* a force! Gilbert knew all too well what force was; by the same token, he knew that life and force are dead set against one another. So, in his detailed description of the power of magnets to magnetize other pieces of iron, he was scrupulously careful to term that power a manifestation of the *life* of the magnet, and to describe that life as the activity of a body containing a soul. For Gilbert, force was only present, or even needed, when something which was alive and ensouled had to control something which was either not alive, and thus not ensouled, or, which was directed contrary to the "natural" impulses of something which was alive and ensouled. And, once again, Gilbert was read, cited, and almost universally approved of by a number of the greatest founders of modern physics prior to Newton. The great cosmologers up to Newton agreed, almost to a man, that life and soul were fundamental givens of the nature which scientific physics studies. Any truly enlightened scientist of our own day, therefore, has very good grounds for *re*-introducing life and soul into the realm of a bonafide science. Portmann is one of the few enlightened scientists of our day who has done this.

Consciousness

Contemporary scientists are not only puzzled by "the emergence of life-"; they are no less puzzled by another, presumably allied, phenomenon, "the emergence of consciousness." Indeed, many of the so-called "hard" scientists, such as bio-chemists and bio-physicists, like to mention these two things in one breath, and to say something like: "The emergence of life and the emergence of consciousness are the only two fundamental problems which science has yet to really begin to conquer." Just as in the case of "the emergence of life", i.e., from non-life, so scientists have set themselves the more or less thankless task of demonstrating how consciousness "emerged" from non-consciousness.

This is a task which has challenged characteristically modern thinkers since the time of Leibniz, who seems to have thought that consciousness emerged from the unconscious as limit-points in the new mathematical calculus, of which he was an inventor, "emerge" from the infinite set of points accumulating about, "in the neighborhood of," those limit points. Given the new discovery of the "little animals" seen through the then recently discovered microscope, Leibniz seems to have thought that the consciousness of the complex organism constructed of these "animals" -- our cells -- indeed, its individual perceptions, were a sort of bio-integral of the "*petits perceptions*" of the animicules or living parts of which the conscious, complex, animal is composed. The "tiny perceptions" of these living components of the complex animals were integrated into a condensation point of a magna-perception -- and *that* is consciousness in the higher organism! (There are still echoes of this approach to be found, in, e.g., *The Lives of the Cell* by Lewis Thomas, M.D.)

A certain good sense on the part of the scientific community as a whole has led them largely to ignore this theory; but this and like approaches have so trivialized the whole question of *how* we should understand the *fact* of consciousness that, although one hears about the "emergence of consciousness," one does not hear very much about it -- except for those theoretical psychologists who deal with dreams and symbols. Even in these, however, in place of widespread scientific and philosophic speculation on the roots of consciousness and its place in the order of things -- i.e., is it a special

or a universal phenomenon, etc.? -- one hears a great deal about the *contents* of consciousness, namely, about symbols. By in large, the scientific treatment of consciousness current today is based on an extremely far-reaching postulate: namely, all the contents of consciousness are symbolic, and the individual elements found in the perceptual field of an individual are all symbols for something which is only of concern to the individual who is perceiving -- and not at all of concern to what is *being* perceived. This infinitely minimizes, not to say trivializes, the fact that we perceive a vastly elaborate manifold of living forms, noises, smells, and colors, and it is just this which is, to Portmann's way of thinking, the worst legacy of modern science's treatment of consciousness as a symbolic organ -- that is, as an organ whose only activity is the presentation of the perceiver's own responses to its environment. The symbolic realm is exclusively of concern to the perceiver and does not, as a symbolic realm, at all concern what is being perceived.

This view of consciousness is coeval with the beginning of modern mathematical physics, that is, with the work of Descartes, during the period principally spanning 1610 to 1645, and, to a somewhat lesser degree, with the work of his immediate predecessor, François Vieta. In the view originating with the mathematical theorists, especially with Descartes, each and every datum of consciousness is a symbol for a (neurological) event which either:

1. originates "outside" and thus, for an event which truly begins only at the moment it begins to "irritate" our sensory apparatus; or,
2. originates in a neurological excitation caused by an endocrine secretion whose presence in the bloodstream is "sensed" by us as an "emotion" or a "subjective state"; or,
3. originates in the centers of the central nervous system concerned with "voluntary motions:" with which we create (ideally mathematical) code-systems for expressing any other datum of consciousness in a way which makes it maximally easy for us to manipulate any datum of consciousness for life-enhancing goals -- a postulate which, in one fell swoop, ties together the symbolic mathematics and mechanistic biology of the modern age.

This last use of our "higher" nervous centers is entirely "symbolic" in the narrowest sense of the term."

In all these cases, *what* we are conscious *of*, a symbol, is said to *re*-present something to us of which we are, outside of some symbolic representation or other, entirely unconscious. Thus, for instance, "pain" is the way in which we are conscious of a real or imagined threat to our physiological and/or physical integrity; it is the way we "naturally," i.e., automatically and without any effort of thought, "symbolize" to ourselves a particular threat to our safety. Likewise, we say that "love" is the way we symbolize to ourselves the heightened level of concentration of any one or more of a certain group of biochemicals which are collectively known as "sex hormones." In the case of so-called "symbolic thinking," a semi-circle, for instance, cut by a straight line erected on its radius, is the way we symbolically represent to ourselves all those *classes* of problems -- truly *species* of problems! -- which can be solved by setting all the parts of the available data in just the relationship to one another which can also be expressed by the "*form*-ula" -- literally, "little species" -- x = (a x b). And, finally, our dreams are the way we symbolically represent to ourselves certain psychodynamically significant relationships such that, even when all direct access to them is blocked, we can become conscious of them, *indirectly*, precisely because we automatically present them to our awareness through dream-symbols.

To sum up, then, the founders of modern science such as Gilbert, Kepler, Galileo, and Descartes did not think that they had to reject soul and life in their physical speculations; some, however, did seem to think that they could do without any non-symbolic consciousness as a fundamental given in nature -- presumably because of their interest in "symbolic" mathematics.

Portmann's scientific work has severely faulted modern science to the extent that it has refused to reconsider whether it was wise to jettison life and soul from the field of science; he has, by the same token, entirely rejected life science's quasi-mathematical treatment of consciousness as the fundamental given with which the lifesciences must begin their work.

Portmann and the Living Thing

For Portmann, the living body is not an event. It is a being of which we can say certain unique things. Among the first of these is that we say a living being can *be to* -- be *this* or *that* to -- other living beings; one living being can relate to or have a relation with or be in a relation to another being. Thus, for instance, supposing that a theoretical biologist has a pet dog; it is certain that this cherished pet and its beloved master have a number of interests which are entirely distinct. The dog's interest in other dogs, let alone in cats, is far different from the interests his biologist master has in these matters. The evolution of dogs, cats and humans from some enormously remote common ancestor involves, for Portmann, their evolution into three largely -- but not entirely -- distinct fields of world-relational possibilities, and not merely, or even primarily, into three examples of more or less successful survival-stratagems.

Portmann sees just this *being to*, which is unique to living beings, as the grounds for saying that the very fact of life implies, i.e., points to the necessity for, the *cognate* fact of consciousness. For, to be conscious of, and to be in such a way as to be the subject of the attention of another conscious being, are, for Portmann, both implicit in the fact that each and every living being has potentially "vital" relationships to other living beings. This holds true, according to him, even though very many species of organisms are not able to fully realize consciousness as an implication of their being alive. Many species of living beings, that is, do not possess central nervous systems which permit them to have living relationships which depend on consciousness.

That the living being is able to enter into *definite* relationships to other living individuals points to the place of self in the living individual. An event, e.g., the meteorite falling in the desert unseen by any eye and unheard by any ear, need not have any relation to anything; a dislocation of sand, even of a great deal of sand, involves no relationships. To relate to one another, two beings must, each of them, possess a self -- indeed, a self-identifying self. Otherwise, that "relation" would either collapse into a nullity or into an identity -- into a nullity if neither had a self, and into an identity if both had an "identical" self. For Portmann, this "logical" truth -- i.e., that two things

must each possess a self in order to relate to one another -- manifests itself in living things through the agency of what he calls the "inwardness" of living bodies. That inwardness, though altogether interior, must reveal itself to "external" living beings, or none of those living individuals could stand in any relationships *to* any other living individual. Thus, Portmann relates inwardness to just that self -- to just that inner centrality -- which is only possessed by living beings as living beings with bodies whose public, visible, exteriors manifest that inwardness to the world at large. Portmann says that the proper study of the way living individuals utilize their bodies to manifest their inwardness is composed of a union of behavioral science and comparative morphology, and that union comprises, for him, the very queen of biological study. Its subject-matter is, for Portmann, far and away the highest function of a living body -- namely, the way living bodies manifest their inwardness through their activities and "looks."

Portmann thinks that the study of that inwardness and the way the individual manifests itself to others constitutes the unique contribution which the biologist can make to the study of the biological soul of the living, visible, body, and he is most clear about the fact that the study of this inwardness is of a higher degree of importance and is ultimately more fruitful of insight than any other study accessible to the life sciences. In this, to be sure, he is in deep disagreement with the tradition of modern thought most current today. For this tradition, life-processes are so much more important as a study for the researcher in life sciences that the whole question of soul has virtually disappeared; indeed, the question of soul has been addressed so little for so long in the life-sciences that, especially in English-speaking countries, the term "soul" has no *biological* meaning at all. For Portmann, however, the term "soul" refers to precisely the foundation for that self-identity of each and every living body which permits the living body to *be to*, or to stand *in* a relation *to*, other living bodies. When the science of our age dispensed with the soul, it made humans and all other animals into mere machines, i.e., into more or less complex systems within which metabolic processes could take place.

The extraordinarily liberal dimension of Portmann's thought is nowhere more clearly identified that in his rejection of biological mechanics as the queen of the life sciences. In his view of the life sciences, the questions concerned with the selfhood of the individual living being, along with the relationships proper to such individuals, stand at the very center of biological investigation. Thus, concerns with metabolism and biochemical processes within the body of the living individual are for him ultimately significant *only* as ancillary processes which permit the living individual to maintain *its* body as the instrument with which it relates itself to *its* world.

Analytic Biology and Evolution

Scientific thinkers since the middle of the 17th century have tended to view all complex entities, living or not, as constructs built up out of simpler elements. It seems probable that this view took its bearings first from the new algebra which addressed the task of discovering all the "roots" or significant elements in any problem; and then, once these "roots" were discovered, algebra showed how to state problems in such a way that the unknown was exactly equal to the knowns.

In all this, to be unknown, and thus to be the subject of a scientific discipline, is to be unknown in terms of simpler knowns. For the scientist since Descartes' great work in the 1630's and 1640's, the task of all technologically-oriented science has been to analyze each and every complex entity, living or not, into simpler components or "roots" or elements, and then to discover ways of using those elements to answer any and all conceivable questions which can be posed about the complex entity. Once we view all living complexes in terms of simpler elements, we can then repair any faults in the given complex entity -- and this is the medical form of this analytic biology -- or we can construct new complexes -- as we do in genetic engineering or even in scientific hybridization.

Darwin and his followers were, almost to a man, remarkably faithful to this program set up most powerfully and clearly by the mathematical physicists such as Descartes -- where the mathematics of their physics was an *analytic* mathematics. It is thus not to be wondered at that first England, and then the rest of industrialized Europe, were delighted by the idea that the

"industrial revolution" was no real revolution at all: mankind was *finally* getting into step with the rest of nature. For Darwin and his scientific followers, truly scientific biology was Cartesian -- although few of them knew very much first hand about Descartes' thought -- and it comprised investigations into what might well be called "bio-constructs." That is, the living thing was viewed by these heirs of the new analytic science of the 17th century as being a construct of precisely the same number of biologically significant elements as there were distinct events in the past which had left permanent additions to or modifications of the simpler "bio-constructs" of an earlier, and hence simpler, time: to be biologically significant is to comprise a trace of a past event which records that past event.

Portmann is a profound scholar of evolution, but he has very deep and far-ranging reservations about this Darwinian view of the living thing as a compound effect of nothing but events of the more or less remote past. For one thing, Portmann is not willing to accept that living reality is precisely what can be constructed -- or, better, *re*-constructed -- by this current theory of evolution. There is no question that, for him, higher life-forms, including *Homo*, evolved out of simple life-forms. Portmann's primary question, however, is: *what*, exactly is the end-product of evolution? And then, *only when* that question has been answered, does he ask: *how* did that end-product get that way? This second question, is absolutely subordinate to the first question. Whereas, on its part, the widely current, more or less strictly Darwinian, theory, *first* asks itself *what* it can explain by means of its methods applied to the (admittedly sparse) geological record, and then, next, it defines its subject-matter as being no more and no less than just what it can explain applying its methods to that very sparse fossil record. As Portmann sees it, however, science cannot properly demand of us that we believe in the existence of only what it happens to be able to construct for us at any given state of science's progress. Rather, he views the subject matter of a given science as strictly antecedent to the science which addresses itself to that subject matter. As a consequence of this view of the issue, Portmann takes the world, especially the world of living beings, as given in its entire familiarity and *there*-ness. These living beings, vividly present as they are, lead the thoughtful and reflective scientist to see that this very familiarity and

thereness point quite precisely to what they hide from us precisely because they are so familiar to us and so vividly obvious. Thus, whereas Galileo said, "Nature likes to hide," Portmann saw that nature likes to reveal, but that very revelation quite often hides precisely what it is which makes that revelation! Rather than anything like an art hiding art -- or, as for Galileo, a natural machination hiding its own complexity -- we have in Portmann's thought a case of appearance hiding *what* appears, and, what is most familiar in our experience of the living world manifesting the strange and apart in it -- i.e., the inwardness and otherness of a living body. This relation of the familiar to what it hides *because* the familiar tends to shield the essentially intimate from view, gives rise to what Portmann terms, "a mystery" and nothing *less* "other-worldly" or superstitious than this can be imagined! In this, Portmann powerfully rejects that view of science which demands that any "genuine" science proceeds reductionalistically and, in its place, he proposes an expansion of the theoretical foundations of life-science such that it can deal effectively with the overwhelmingly obvious world of appearances with this given world here in front of us; the science he proposes must be able to begin, and end, with the given, with the *there* world of appearances. For him, however, that world of appearance, precisely because it is a world of appearance, points to the way in which something which is not an appearance can relate itself to the world around us through appearance. This is the ultimate rationale for Portmann's radical modification of reductionalist life science.

In this view, then, life science is ultimately engaged in the search for the inwardness, the centrality, of each living individual. It is with these that each living individual enters into a relation with another living individual -- without either individual losing its individuality. The highest form of that relation is our specifically human knowledge of just that world which, although not obvious itself, nevertheless manifests itself through the obvious.

Species: Portmann and Darwin

For Portmann, the fundamental phenomenon to be addressed by the life sciences is given to us in our experience that living individuals are found to be more or less easily grouped together according to certain more or less

obvious similarities with one another; those individuals together form groups, the "species"; and these, for Portmann, are a true subject for scientific investigation. Indeed, there exists for Portmann a new life science, comprised of behavioral research together with comparative morphology, which, he says, rivals Newton's and Einstein's contributions to science. That science shows us that, within a given species, and especially within species of so-called "social animals", there exist an enormous number of instruments which individuals use to establish relations between themselves and other individuals and, as in migrating birds, even between individuals and the *appearance* provided by the "pictures" formed by groups of stars! *Which* instruments any individual will possess to establish its relations to the world is, however, entirely a function of what *species* it belongs to. The species to which any individual belongs determines the contents of its array of organs with which it can establish its relationships to other individuals and to the world precisely insofar as it has true relationships to that world.

Consonant with this account of species, they appear as fundamentally dynamic realities, so that, for example, the various angles at which a wolf's tail is seen to be raised or the angles of its ears relative to the plane of the top of its skull, help to indicate to another individual its mode *at a given time*; the degrees to which its fur lies flat on a given individual's back or on its tail; or, the changes of the individual's color to express *changes* of inner moods such as we find occur particularly strikingly among species as widely separated as the cephalopods and humans; all these serve as true organs, instruments, for producing dynamic, vital, bonds between individuals either of the same species or, as can happen, even between individuals of entirely distinct species. (And, once again, in some birds, their perception of the mere aspect of the constellations in the night sky is manifested by the course of their migratory flights. *What* they perceive in the night sky above them is clearly manifested in the course their migratory flight takes.)

The sensitivity of a member of, for instance, a *social* species, to manifestations of inner moods by others of its species is a sensitivity founded on the kind of individual involved, and it is that individual's *species* which determines that this individual even *can* express its inner moods to other more or less "moody" individuals in such and such a way, and, contrariwise, that it spontaneously perceives *other* individuals' activities as expressions of

their inner moods; an individual's species determines that these activities are perceived as directed to, or, at the least, as significant for, the perceiver; so that, for instance, all the training in the world will still leave a dog bored with ballet. That this inner bond between individuals is also found between individuals even of widely separated species is shown in, for instance, the relation between a bird, the so-called "Honey Guide" (*Indicatoridae*) and the Honey Badger, or even honey-loving human beings; for, a variety of these birds leads honey-seeking predators to bees' nests for as far as a mile and then, after the relatively powerful or cunning predator has torn the nest apart and scattered its contents on the ground, the bird feasts on the leavings. And, finally, we see what is perhaps the most extreme trans-specific relation -- that of migrating birds and their response to the "signs" in the heavens, an example which points to the immense importance of "appearance" in relating a living being to the world around it.

This inborn sensitivity of a member of a species to manifestations of inner moods by other living things is a sensitivity *entirely* based on the *kind* of individual a given animal happens to be. For Portmann, once again, being alive is an activity rather than an event, and that activity almost always involves the individual's actively *being to*, *relating to*, other living individuals. The individual's self-identity -- which is, as we have remarked, the necessary foundation for any living being to *be in* a relation *to* any other being -- relates the individual to other individuals, and, Portmann concludes, an individual of a species of animal may be said to live within a "pre-arranged" relationship to its world in its species-determinate way. Its species is thus what gives the living individual its world.

It follows from this that the individual is not primarily related to the world around it as prey to predator, although that certainly is one possible relationship; but even in that most simple and widely spread of cases, the prey is the *kind* of prey that it is to the *kind* of predator that preys on it. But, rather than merely locate an individual as prey to another kind of individual, the species of an individual, according to Portmann, gives its entire world to that individual -- that is, it gives the individual, *in its full individuality*, its relation to that particular world, in all its generality, which is essentially complementary to the core of its individuality, its self-identity -- and it

thereby gives that individual, in all its individuality, *to* its world, and its world *to* it.

According to Portmann, what a living individual possesses that makes it appear as belonging to a distinct species is precisely what provides it with instruments by means of which it establishes its "specific" world-relations.

The appearance of the individual, its *species* (Latin), or *eidos* (Greek), is thus precisely that element in the "look" of the individual which points outward and ties it to the world around it. The species of an animal is whatever it is in its (quite often optically) significant endowments that ties it to the world it inhabits as a living individual; the species of the individual is what binds its essentially private self-identity and inwardness to the essentially shared, "public," world around it. Because of its species, the individual's inner reality serves as the center for just that world which includes *precisely* what the individual's species permits it to act as center to. The species to which a given individual belongs is just that in the given individual which makes no sense without *other* individuals, without a *populated* world. And since, once again, the selfsame individual relates to different aspects of its world in different ways and to the same aspects in different ways, that species has an essentially dynamic character. Thus, the corpse of a once-living individual can, at best, only remind its viewer of the species to which that living individual *formerly* belonged. Species are, to be precise, only species of living individuals in a world in which different kinds of living individuals *live* differently. The species to which an individual belongs thus provides the condition for something to take place because a certain kind of individual is at a given place, as center, at a given time. A species, for Portmann, is thus anything but an abstraction *from* individuals. The specific character of the looks of a living individual provides the pre-condition for precisely that species-determinate activity which results in the individual's living within its relationships to the world around it. The biological, i.e., *living*, form defines the limits of the ways the individual can manifest itself to the world around it, to *its* world, and the self-identity of the individual operates within precisely those limits to express itself and to be related to that world. A biological species is thus an anticipation, and, as such, can never be grasped accurately as an abstract, static, form. It is the

ultimate limit of all possible activity of the living individual so that, for instance, the courtship activities of the bowerbird are far different from those of the peacock; what we observe in each instance is pre-determined by the species of the individual which is expressing its inner moods and disposition in its courtship activity.

Most readers will be disposed to view the question of species through their more or less direct acquaintance with Darwin's thought as contained in his *The Origin of Species*. It thus seems appropriate to conclude this section on species with remarks on our present-day Darwinism in so far as it directly concerns itself with the question of species -- *not* in order to take issue with that point of view, but only by way of introductory clarification.

In the Darwinian point of view, a given biological specimen provides the biological investigator with the bio-historical sum of the solutions to life-threats which the genetic precursors of that specimen faced successfully; allied or collateral species of individuals represent, therefore, merely alternative solutions to more or less similar threats to life which have been successfully overcome in the more or less remote geophysical past. Then, the *complexity* of the organization of the body of such a biological "solution-sum" -- which is composed of a set of successive survival-oriented adaptations -- is viewed as representing the *record* of layers of successful additions engrafted onto a series of earlier, already operative set of adaptations. Consequently, the life-processes and activities of the highest mammals -- including, of course, the human species which includes biologists -- are, *in principle*, essentially only complex forms of merely simpler survival-enhancing mechanisms to be found in, e.g., marine annelids, sharks, or even biologists *and* their laboratory rats.

For Portmann, the matter is far different. Higher forms, and especially the mammals, *are* higher because their relation *to* the world is more inclusive -- as Portmann says, "richer." This means that the species represented in these higher forms are more inclusive of other species than is the case with less complex, less highly formed, species. For Portmann, the Darwinian account of evolution as representing only the record or successful adaptations to life-threats must be enormously augmented by an essentially morphological interpretation of the successive developments within any given

species -- where, once again, a species is the subject matter of that scientific discipline formed by the union of comparative morphology and behavioral science. In his view, what is more, the human species *can* include biologists who are morphologists and animal taxonomists, etc., precisely because of their species -- which includes all other species to precisely the extent that they are all accessible to the researchers in the life sciences, philosophy, and the like. *Homo sapiens* as potentially knowledgeable stands in an infinitely richer relation to all other species than any other species of individual; the species-determinate organ which permits us human to possess this extraordinary richness of relation is whatever it is which determines our capacity to be morphologists, taxonomists, philosophers, and the like. This involves us in an amazingly broad spectrum of kinds of living beings *to* which we *can* be related.

To be most fully alive as a member of the human species demands, for Portmann, that we be moved to our species-determinate activities by those very *preconditions for being to* -- for having particular relationships to -- other self-identical individuals. To the extent that we are actualized in our capacity to be active in this manner, we impose upon ourselves the mode of being of other kinds of living beings -- so that, for instance, when we name living things, especially those living things which are neither food nor of even potential danger to us, we thereby manifest that these living things *are* truly something to us. In this most radical of ways, a human can be said truly to live life to an extent that is not even remotely approximated to by an individual belonging to any other species of animal. In the case of all other animals around us, there exist species outside their *possible* interest; we humans, alone, relate to the world in a way strictly predetermined by the species we are, namely, by the species with an enormously wider inclusiveness than is to be found in any other species.

Thus, for Portmann, the human species is the speculative species; to be human is not only to possess the impulse to show ourselves as being human in widely different ways. For it does more than span the modes of self-decoration of the drab garb of the Sicilian widow and the superb flamboyance of the young Zulu warrior. It also includes the greatest degree of species-determinate speculation, namely, our speculation spanning

anthropological studies of both Sicily and South Africa, and even reaching "down" to the comparative anatomy of the larynx of the climbing perch and the wombat, (E. V. Negus' great work!). Our human species, with its enormously complex higher central nervous system, is the species of species, the speculative species whose biologically unique specifying activity is a speculation on the way species relate to one another: Portmann's comparative morphology, built as it is on the results of behavioral science, is the science which permits its species-determinate practitioners to engage in a speculation on species.

For Portmann, nature is far more than a power to metabolize together with a realm of potential material for the individual to consume and transform more, that is, that a sum total of all possible predators and prey. For Portmann, nature includes, at its very center, an enormous potential for self-differentiation, along with the cognate power of self-expression; it essentially involves forms and the power to grasp them through consciousness. A form, for Portmann, is active; it is precisely out of the activity of those formal powers that the astonishing richness of living forms comes to be present to us as conscious beings. This potential for self-expression and self-differentiation is, for him, the central force behind the astonishingly varied and rich manifold of life-forms -- as opposed, once again, to the force for maintaining metabolic systems intact. These life-forms have been entirely ignored by contemporary biological research precisely because they hold it as a postulate that all that nature preserves is the metabolic system; thus, any question of why the individual has evolved such and such a form never is asked. But Portmann asks just that question: how is it that the mechanisms of evolution include a vast potentiality for transformation of outer form -- as opposed to merely the transformation of metabolic systems within the animal? As the author of *Animals Forms and Patterns*, no less than of *Animal Camouflage*, Portmann is by no means ignorant of the life-preservative nature of many forms. But, he insists, that nature includes such a vast armamentarium of forms and patterns in its war-chest is something which has not been considered much at all. The evolution of form and the evolution of consciousness which can grasp those evolved forms, are cognate facts of biological science which are, to his mind, vastly more central to

evolution than questions concerned with self-maintaining metabolic systems. Thus, for Portmann, the power of self maintenance is, first, last, and always, the power to maintain a self-differentiating, self-expressing living being. Living form and that dynamic centrality or inwardness delineated by living form thus become the center of interest for that life science which is, for Portmann, the most all-inclusive: the science composed by the union of comparative morphology and bio-behavioral science. Then, the so-called "hard" sciences such as biophysics and biochemistry are, within this schematic for a new and all embracing life science, seen as essentially ancillary to -- i.e., in the service of -- this new science whose goal it is to understand the power of the central life-phenomena of self-differentiation and self-expression to give the individual a world of its own.

Form and the Evolution of Consciousness

The historical course of evolution involves, for Portmann, the sequential development of organisms whose inner structures permit processes to arise which support the vast array of (often riotously colored!) living forms which daily confront us as conscious individuals. Each of those forms is a *living* form to the extent that the activities of their individual possessors essentially express the dynamic capacity of the individual possessing just this form to inhabit the world it does *because* it has that form.

As Portmann's essay, "What does the Living Form Mean to Us?" points out, we find instances of self-expression through form-differentiation even in lowly sea anemones, in forms, that is, which only a very careful marine biologist who is interested in taxonomy and morphology would ever be likely to detect; form-differentiation in such simple and ancient life-forms thus *anticipates* the evolution of structures complex enough to consciously grasp them. For Portmann, that is, geological cataclysms and the like are not the primary external evolutionary selectors and guides; rather, a very large number of species have evolved just those mechanisms within the central nervous system which permit *consciousness* of form-differentiation in other individuals. form-differentiation and the evolution of consciousness are, therefore, essentially cognate: form-differentiation anticipates the evolution of consciousness.

To sum up, then, for Portmann the "higher consciousness centers" were not evolved merely to permit their possessors to detect predators and/or prey so that the fortunate possessors of such higher consciousness centers were better able to maintain those centers in the face of threats to continued conscious existence. Rather, those centers *primarily* represent to Portmann the supreme biological complement to and fulfillment of the riot of shapes and colors, sounds and smells, which the world of living beings presents to the fortunate possessor of those higher consciousness centers.

In the final analysis, it is only that speculative human scientist who permits himself or herself to reflect on this wonderful parity between form and consciousness who can grasp what is, for Portmann, the greatest of the mysteries scientific biology has uncovered: the mysterious drama of the anticipated reflecting on its own anticipation. Thus, for instance, Adolf Portmann himself, as he carefully and minutely searches out the formal marks discriminating a given variety of sea urchin from other varieties, provides us with a clear instance of the anticipated reflecting on its own anticipation. (In strict accord with this picture, we find Portmann's anthropology showing us the human newborn, within what he calls the "social womb", as the anticipated human being made human in its being anticipated by its parents and family members; the human being that a newborn can become is anticipated in the care and nurture its parents give to it.)

In short, for Portmann the most perfect fulfillment of the life-forms studied by the life sciences is to be found in the active contemplation of those life-forms by the reflective human. In his life of research, teaching and writing, Adolf Portmann both actively contemplated those life-forms and then handed down to us the most delectable fruits of that labor in his anticipation of generations of yet unborn humans who might better fulfill their humanness as active speculators rather than as rapacious bio engineers.

INDEX

A

a "front", 25
accord of the formally significant with the materially significant, 164
acculturisation, 97
acid, acetic, 62
acid, hydrocyanic, 63
acid, ribonucleic, 53
acids, amino, 62
acoustical modes, 30
acoustical recognition, 33
acquisition of human traditions, Intro., Part III
activity, glandular, 55
adult hearing threshold, 114
aesthetic experience, 149
age of slogans, 141
albumen serum, 125
alchemist, 168
alchemy, 164, 172
"alien knowledge", 40
all is leaf, 163
"all is leaf", 161
Altdorfer, 158
ammonia, 62
amphibia, 159
Amphioxus, 75
anal pole, 76
analogy, gentle empiricism of, 168
analphabetic form for what is alive, 172
analytical investigations, 58
anaphony, 31, 32, 33
anathropoids, 100
anatomy of a caterpillar, 159
androgyne, 22, 167
angiosperms, (blooming plants), 161
animal behavior, 86
animal man, 132
animal men, 130
animals, territorial property of, 89
annual herbs, 161
annuals, blossoming, 162, 167
Antarctic sea swallow, 15
antelope, 148
anterior pole, 76
anthropoid apes, 101
anthropoid apes, vocal organs of, 99
anthropoids, 105, 107
anthropology, 132
anti-classicists, 156
Anzenbacher, H., 122
Ape Societies, 123
apes, 99, 100, 106, 111, 127, 136,
apes, anthropoid, 102, 105, 107, 117, 125, 126, 128-135
apes, female anthropoid, 126
apes, old world, 133
apes, ontogenesis of all, 133
apes, ontogenesis of the anthropoid, 133
apotheosis in fertilization, 168
apparatus, skeletal-muscular, 52
appearance as self-representation, 155
appearance, 25, 139
appearance, devaluation of, 27
appearance, living, 151
appearance, organs of, 155
appearance, total, 37
appearances, form-structure, 143
appearances, subjective, 50
Arber, Agnes, 158, 160, 163, Appendix II
archaic fish, 75
archaic form, 16
archaic human, 17
archaic nursing forms, 112
archaic system, 17
archetype, 35, 40
archimedean principle of weight reduction, 113
architects, 151
architecture, physiologically oriented thinking in, 151

Archives for Developmental Mechanics, 49
art nouveau style, 150
arthropods, 21
articulated word-speech, 116
artificial models of blossoms, 153
astrocosmic vision, 18
asymmetry, 24
Australopithecenes, 102
Australopithecines, 134
Australopithecus, 116
authentic "inside", 25

B

baboons, 133
bacteria, 53, 60
bacteriology, 84
Bauman, F., 43
Becquerel, 61
behavior, 56, 87
behavior, animal, 49
behavior, anticipated structure of a, 40
behavior, eccentric, 136
behavioral research, 36, 56, 166
behavioral science, 125
behavioral, 171
Beklemishev, W. N., 93
Berendes, J., 122
bilateral, 24
biochemistry, 59, 171, Intro., Part II
biochemists, 125
biology molecular, 52
biology, 137
Biology, General, 54
biology, molecular, 53
biology, theologically oriented, 149
biophysics, 84, Intro., Part II
bioposesis, 61
biotechnics, 59
biotechnology, 138, 172
bird's song, 142
bisexual, 22
"biting", 41
blood, 85, 142
blossom characteristics, 153
blossoming annuals, 170
"blue-prints", 53
Blue Thrush, The Love Life of the, 166
blushing, 28
bodies, human political, 51
Bolk, Louis, 101, 122
bones, 52
Borneo, 105
Bosch, Hieronymus, 156
Botanical Garden of Padua, 160
Botany, 48
both this and this, 141, 142
boundary, 26
brain capacity, 128
brain development, species-determinate, 131
brain formation, 119
brain growth, post-embryonic, 130
brain index, 117
brain masses, 118
brain size of humans at birth, 116
brain structures, 127
brain weight, 129, 131
brain, 75, 99, 114, 130
brain, accelerated growth rate of the, 135
brain, evolution of the, 119, 133
breast-thumping, 104
Breughel, Peter, 156
Bronn, G. H., 61
buck's antlers, 142
buck, antlers of a, 141
building block, 84
building blocks, cells as, 85
butterflies, 27
butterfly's wing, 83, 154
butterfly, 159

C

calves, 130
calyx, 1686
Camerarious, 169
camouflage, 74
Camper, 99
Camper, P., 121
carbon dioxide, 64
castration, 142
caudal pole, 76
cell and plasma research, 79
cell states, organism as a, 81
cell, 36, 79, 84
cell, state, 82
cell-state, dogma, 82
cell-states, 80
cells, 81
cellular activity, 169
centers, active, 90
central nervous system, 134, 136
centrality, 26, 28, 33, 37
chat's, 11
chat, 11
chats, 10
chemical contacts, 28
chemical influences, 22
chemical stimulants, 21
chemistry, physical, 50
childish relation to the world, 136
Chimpanzee, 121, 123
chimpanzee, 129, 130
chimpanzees, 103-106, 125, 128, 131
chirping-apparatus, 34
chlorophyll, 64
chloroplasts, 55, 64
Cholinesterinase-Active Elements in the Muscle, 122
Chorthippus montanus, 32
Christ, 147
Christianity, 60
chromosomes, 55, 84
Clauser, G., 102, 122, 123
clear types, 162
closed sense-organs, 130
cocoon, 82
colonies, 80
communal life, 26
communication among members of the same species, 140
communication, living, 97
communication, pre-verbal, 113
comparative morphology, 56, 74, 133, 162
compartmentalization of various attributes, 141
comprehensive morphology, 155
concentric animal being, 136
conquest of heaviness, 150
consciousness, 26, 49, 58, 72
constellations, 8, 9, 10, 12, 14
construction, hermaphroditic, 73
contemporary natural science, 164
Copernician world-view, 18
cormorants, 29
corolla, 168
correlation of brain and body size at birth, 133
counting, 113
Cranach, 158
crane's dance, 142
creation, 60, 80
creation, doctrine of, 66
culture, concept of, 165
culture, human, 165, 173
cybernetic machines, 12-13
cylinder of airspace, 90
cytology, 80
cytoplasm, 53

D

Darwin Centenary Celebration, 62
Darwin's theory of descent, 149
Darwin, 60, 67, 68, 70, 74, 80, 162
Darwinism, 60, 69
Dayton, 165
de Candolle, Aug. Pyrame, 161
de Candolle, Casimir, 163

death, 54
deer, 130, 141
defense mechanism, 148
dental arch, human 101
dental arches, special ontogenesis of the, 102
dependencies, ecological, 73
dependency, life-furthering, 81
Descartes, 99
development, brain, 128
development, Death as a law of inner, 156
development, early period of mammalian, 111
development, human laryngeal, 110
development, human, 125
developmental processes in living things, relative autonomy of, 87
dicotyledonous angio-spermae, 170
Die Metamorphose der Pflanzen, The Metamorphosis of Plants, 159
Dietz, R. S., 123
digestive enzymes, 92
dimorphism, sexual, 73
display characteristics, 148
display coloration, 74
display, 26
display, blossom, 153
display, realm of color and, 154
diurnal, 17
division of labor, 81
DNA, 53
dolphin, 113, 114, 115
Dolphin, 124
dolphin, Tursiops, 116
dolphins, 119, 148
Dolphins, Sporting, 115
domain of events, macromolecular, 54
domain, molecular, 54
domination, 141
double-rhythm heartbeat, 109
Dr. Sauer's, 8
drama of hunter and hunted, 166
drink compulsion, 112, Intro., Part III
Duerer, 150
Duino Elegies, 158
duplication, 53
dynamic being, 141
dynamic morphology, 85
dynamic order, 14

E

ear, movable portions of the, 140
early age of wonder, 135
earthly objects, sensed singularity of, 87
echo direction-finding, 115
ecology, 56
economic role, 59
electron microscopic visibility, 54, 55
elementary organism, 36
elementary powers, 157
elements, self-increasing, 54
elephant, 130, 137
elephant, Indian, 114
elephant, trunk of an, 136
elephants, tusks of, 142
Eliade, 176
embryo, human, 136
embryonic stage, 38
emotions, inner, 140
"end" brain, 75
endoplastic reticulum, 55
environment of the unborn, 109
environment, 88, 90
environment, social, 128
environment-bound, 136
enzyme action, 53
enzymes, 57
epiglottis, 100, 111, 127
Eranos, 42
Eranos-circle, 42
Eric Neumann, 40
eternal diastole and systole, 171
events, plasma, 52
events, protoplasmic, 51

evolution leading to man, 126
evolution of forms, 74
evolution, 39, 56, 66, 71, 97, 118, 143
evolution, accelerated, 97
evolution, human, 118, 136
evolution, Intro., Part III
evolution, mammalian, 112
evolution, new theory of, 69
"evolution, synthetic theory of", 69
evolution, theory of, 134, 162
evolutionary events, complementary, harmonious currents in, 76
evolutionary processes, physical-chemical explanation of, 87
evolutionary theory, 70
evolutionary theory, general, 70
evolutionary theory, special, 69
exchange-singing or anaphony, 31
experience conscious, 50
experience, center of, 90
experience, great basic forms of, 172
experiences, inner, 138
expression of an inner state of being of the organism, 153
extra-terrestrial journeys, 18
eye-teeth, 101

F

facade, 151, 155
facial skin, 28
falling stars, 9
Far East, 42
Farbenlehre, (Theory of Colors), 159, 168
featureless Germany, 160
Fechner, G. Th. 48
feeling for definite proportion, 150
female song, 33
fermentation, 51
fertilization, 73
fetal characteristics, 107
fetal growth, 129
fetal period, 107
fetus, Intro., Part III
fetus, mass increase of, 129
fibrils, 55
field of hearing, structured, 33
field of potentialities, 15
fine arts, 156
fins, 118, 119
first, extra-uterine, year, 136
flatworms, 25
"flower nuptials", 169
flower, 169
flower, miracle of the, 168
flowers, beauty of, 139
fly egg, 82
foals, 130
force of gravity, 21
force-field, 10
form of being, snake's, 41
form of life, 89
form of life, intellectual and spiritual, 134
form of life, pre-hominid, 126
form structure, exploration of, 140
form, the climactic, 167
form, 14, 171
form, basic leaf, 162
form, functional sense of, 150
form, living, 140, 151, 155
form, natural interrelation of, 162
form, natural, 156, 157
form, objective experience of, 164
form, problem of living, 154
form, purposive, 149
form, shape-producing power of a closed, 149
form, specific, 65
form, torpedo, 118
form, transformation of one consistent basic, 162
form, wild, 165
form-construct, 34, 38
form-construct, mature, 34
form-construction, polar phenomenon of, 75
form-constructs, variation among, 162

form-phenomena, 154
form-rich Italy, 160
form-structure (gestalt), 137
form-structure, 23, 138
form-structure, organic, 140
form-structures, 27, 140, 141
form-transformation, 169
formal elements, interdependency of, 76
formation of the flower, 164
formation, flower, 170
formation, inner law of, 162
formations, ornamentally effective, 152
forms of being, semi-liquid, macro-molecular, 13
forms of birds, flight, 150
forms, ape-like, 118
forms, elemental, 154
forms, favored, 150
forms, foreign, 155
forms, general relationship of, 126
forms, living, 72, 154, 157, 173
forms, milk drinking, 111
forms, natural, 155
forms, privileged, 151
forms, quadratic, 150
forms, reptilian, 111
forms, rich existence of manifold, 154
forms, streamlined, 150
Fossey, Dian, 122
Fossey, Diane, 104
Fossil Man, 122
fossil remains, 111
fossils, 67
freedom, 154
frog, 159
fruit, 170
function, 14
function, excesses of utilitarian interpretation concerning, 149
function, form and, 149
functional interpretation, 148, 149
functionless, 5
functions, form-selection as a vehicle for, 149
functions, life-preservative, 56
funtional Morphology, 149

G

Gardner, Allen R., 105
Gardner, Beatrice T., 105
Gardner, R. A. and B. T., 123, 128
Gardners, 115
generation, abiotic, 60
generation, spontaneous, 60
generative pole, 76
genes, 36
genetic structures (genome), 135
geneticists, 125
genetics, 48, 73, 74, 118
genetics, modern, 138
genetics, population, 70
geological history, 118
geological time, gradual form-change within, 162
geometrical regularity, 24
gestation time, 131
gesture, 104
gestures, 98, 117
gibbons, 133
glands, epidermal, 41
God and man, unification of, 170
God, manifestation of our, 171
Goerttler, K., 102
Goethe, 153, 159-165, 167-172
Goethe, Intro., Part IV
Golden Mean, 158
gorilla, 104, 129
gorillas, 125, 131
Görttler, Kurt, 110, 122
grades of living things, 51
grasshopper song, 33
grasshopper, 31, 34
grasshopper, field, 30
grasshopper-violin, 34
grasshoppers, 30, 33

grasshoppers, female, 33
green monkeys, 133
Grew, Mehemiah, 161
grey parrot, 113
greyhound, 150
greyhounds, 148
groups of moods, 35
growth, slowing down of our, 135
growth-rate, fetal, 129
gullet, 100

H

hair, ornamental wreathing of, 76
Haldane, 61
Haldane, J. S., 57
hand and foot, 118
hand, 119
handling, 119
Hartmann, M., 43
Hasse, C., 121
headpole, 75, 76
hearing-world, 115
heart pulse, early uterine "experience" of the mother's, 109
heart rhythm, mother's, 110
heart rhythm, sound of the, 109
heartbeat, 108, 109
heartbeat, mother's, 108
heat and radiation, 31
hedge-sparrow, 91
hedgehogs, 118
Hediger, 142
helpless lion cubs, 147
Henschel, Aug. Wilh., 169
Heracleitus, 50
hereditarily prepared relationships, 15
heredity, 12
hermaphroditic, 22
Hess, J., 123
histology, 80
Holy Ghost, 147
hominid line, 125
hominids, genuine, 133
hominization, 119
Hominization, 16
Homo erectus, 116
homosexual attachments, 29
hormonal rhythm, 7
hormonal system, 13
hormones, 92, 142
horns, 74
horse skeleton, 165
Hovhaness, Alan, 117
Howe, Margaret, 115, 116
Howes, 100
Howes, G. B., 121
hulls, 79
human behavior, 132
human being, social life of, 92
human beings, relationships between, 166
human children, 132
human children, mass increase of, 129
human culture, Intro., Part III
human evolution, Intro., Part III
human medicine, 149
human offspring, 131, 135
human openness, 35
human racial history, 102
human society, 81
human speech, 99
human speech, Intro., Part III
human thinking, archaic forms of, 66
humanity *as it is given*, 134
humanization of animal life, impermissible, 89
humanization, 102
humans, evolution of, 119
humans, particular path of, 135
humpback whale, 124
hunches, 72
Hunter, John, 101
Husson, R., 102, 122
Huxley, A., 43
hydrocarbons, 61

hydrogen, free, 62
"hypertelic", 56

I

I-functions, 98
imagination, 60, 98
imagination, alchemical, 164
imagination, creative, 172
imagination, spiritual worlds of, 119
imitation and tradition, 129
"immortality", 54
inborn picture, 9
individual and kind, comprehensive polarity of, 76
individual being, manifestation of, 76
individual vertebrae, 163
individual worth, 29
individual, concept of the, 54
individuality, 81
individuality, lack of, 54
individuality, troublesome, 82
individuals, 54
influence, chemical, 22
Information Theory, 53
inheritance social kind of, 97
inheritance, Mendelian laws of, 68
inherited changes, chemically induced, 69
inherited modification, domain of, 91
"inner clock", 66
inner *milieu*, 22
inner realities experiencing their worlds, 143
inner state, 35
inorganic, 60
insects, 30, 159
"instrumental", 52
instrument of allurement, 148
intellectual and spiritual development, 136
intellectual and spiritual horizons, 155
intellectual and spiritual, 137
interdependency of living things, 37
international legal issue, 155
investigations of nature, causal-analytical, 76
inwardness, 1, 3, 4, 6, 12, 15, 16, 25, 26, 28, 30, 37, 38, 57, 65, 71, 171
"inwardness", Intro., Part II
inwardness, non-spatial, 33
inwardness, sensitive, 25
irritability, 65
"irritability", 57

J

Jacobs, N., 43
jellyfish, 21, 152

K

Keleman, G., 121
Kipp, F. A., 122
Kipps, 101, 102
Koelreuter, 169
Köhler, O., 123
Konrad Christian Sprengel, 169, 170
Kortland, 29
Kortland, A., 43
Kortlandt, 104
Kortlandt, A., 122
Kummer, 121

L

labor, division of, 51
labor, social division of, 51
Lamark, 67
Lange, E. von, 129
language of the eyes, 172
language, American deaf and dumb, 105

language, ape, 99
languages, 97
larks, 91
larva stage, 34
larva, 82
laryngeal descent, 102
laryngeal surgery, 103
Larynial Muscles, 122
larynx, 99, 100, 112, 115, 119, 127
larynx, decent of the, 108, 119, 127, 134
larynx, Intro., Part III
larynx, late descent of the, 111
laws of form, 24
leaf appendages, 163
leaf forms, 167
leaf, climactic, 167
leaf-green, 65
learning, 35
leaves, blade-shaped, 162, 163
leaves, different orders of, 167
leaves, green world of, 153
leaves, seed, 169
leaves, shape of, 153
level of life, macromolecular, 60
level of living, macromolecular, 54
level, macromolecular, 52, 53, 57
lever, laws of the, 55
Lieberman, 100-102
Lieberman, Ph., H., 121
life, antediluvian, 67
life, revealed mystery of, 173
life-functions, "elementary", 51
light, activities and passivities of, 164
Lilly, 116
Lilly, John C., 115, 124
limb mass, ratio of trunk, 130
limbs, forward, 118
limbs, hind, 118
linguistic usage, 84
Linnaeus, 169, 170
living creation, 171
living form, 15, 147
living function, 151
living matter, instrumental level of, 54
living processes, proper hierarchy of, 59
living reality of the organism as a totality, 138
living space, special, 89
living structure, enigmatic character of the oneness of a, 138
living structures, self-centered activity of, 86
living substances structure of, 85
living things, form-production of, 154
long call, 105
Lucy, 117
lumbar region of the spinal column, 136
Lyonnet, 159

M

ma-ma, pa-pa, 110
macaque, 130
Macaques, 101
macaques, 130, 133
MacKinnon, 105
MacKinnon, J., 123
"macromolecular", 52
macromolecular sphere, 55
macromolecule, 84
macromolecules, 85
macromolecules, proto-vital, 61
magic words, 82
magnetism, 10
"mal-arial", 60
male organs, 22
Malpighi, 161
mammal, water, 113
mammalian type, 100
mammalians, ancestors of the, 131
mammals, 100, 108, 113, 135
mammals, evolution of, Intro., Part III
mammals, higher, 132

mammals, movable portion of the outer ear of, 139
mammals, origin of speech in, 116
mammals, pouched, 127
mammals, water, 118
man animals, 130
man of genius, 113
manifestations, "functionless", 98
manifesto, 23
manipulation, 119
mankind, origin of, 134
mannerism, 156
material, viral, 53, 61
mating play of the stickleback, 166
matter, proto-vital, 62, 63
matter, refining and purification of, 164
meadow lark, 90
medicine, 56, 139
membrane, boundary, 65
men, wild, 126
mescaline, 22
metabolis, development, and reproduction, 139
metabolism, 36, 39, 48, 57, 58, 59
metabolism, organs of, 23, 24
metamorhposis, 161
Metamorphosis of Plants, 172, 173, Appendix II
metamorphosis, 153, 159, 160, 163
Metamorphosis, Intro, Part IV
metamorphosis, plant, 171
metamorphosis, serial, 160
methane, 61, 62
methodological presuppositions, 37
miasmas, 60
mice, 41
microbiology, 53, 171
microscope, 79
microscope, electron, 52, 84
microscope, light, 52, 84, 85
microscopic limits, 85
Miescher, Fr., 53
migatory birds, 18
migration, 8, 9, 10
migration, bird, 38
migration, nocturnal, 8
migration-orientation, 13, 15
migrations, insect, 13
migratory birds, 14
Milky Way, 12
Miller, Stanley, 62
mimetic communication, 104
miracles, 60
Mircea, 176
mirror-symmetries, 76
mitochondria, 55
Moby Dick, 117
mode of thought, 161
molecular biologist, 166
Molecular biology, 53
molecular biology, 74
molecular laws, 53
molecular research, 171
molecular world, 156
monandria-monogynia, 170
monkeys, Rhesus, 101
monogamy, 170
monotheistic religions, 17
mood, 28, 35
morphological investigation, 74
morphologist, 153
morphology, 76, 140, 141, 159, 163, 164, 171
Morphology, 39, 55,
morphology, scientific, 160
Moscow Congress of 1957, 62
"motif", 32
Mountain Gorillas, 122
mouse, 40
mucosa reabsorbing, 55
mud, 60
MÜller, Fabiola, 123
Muntjak, 141
musical form-motifs, pre-determined, 91
musk-ox, Tibetan, 141
mutation rates, 125
mutational events, 71
mutations, 36, 70, 138

mute "larva-song", 34
myeline sheath, 108
mysteries, 18
mystery, 7, 15, 35, 61, 119

N

naive original world picture, 135
nasal cavity, 100
natural science, 159
natural science, Goethe's work in, 166
natural selection, 149
natural semophore, 148
nature as the mirror of a higher spiritual world, 148
nature, alchemical interpretation of, 164
nature, privileged forms of, 165
Nauck, E. T., 121
navigation, 5, 12
navigational abilities, 16
Neanderthal man, 102
"Neo-Darwinism", 69, 71
nerve, auditory, 108
nerve, vestibular, 108
nervous system, 118
Nervus accessorius of the Vagus, 102
nest squatters, (altricials), 130
nest-fleers (precocials), 111
nest-huggers (altricials), 111
new hierarchy, 37
new order of magnitude, 84
new relational modes, 35
new scale of worth, 143
newborn humans, 100
Newton, 176
nocturnal, 17
non-spiritual substances, 164
northern temperate zone, 13
Northrop, 98
Northrop, F. S. C., 121
nourishment, 55
nuclear biology, 84
nucleic acids, 47
nucleus of ova and semen, 135
"*nucleus vegativius*", 23
nucleus, 79 80
nucleus, 84
nucleus, cell, 71, 73, 84
nucleus-areas, organ-forming, 82
number, 113
numbers, seeing or hearing of, 113
nursing, 100, 110, 111
Nursing-Ontogenetic Types, 123

O

Oedipoda type, 31
old morphology, 162
onotogenetic precendents, 39
ontogenesis, 133, 135
ontogenesis, evolution of our, 132
ontogenetic phenomenon, 134
opaque, 24, 26, 35
Oparin, 61
open positions, 35
openness, 42
Ophryotrocha puerilis, 22
optical modes, 29
optical structures, 26
Orangutan's, 123
orangutan, 105, 121, 129,
Orangutan, 99
orangutans, 131
order of reason, 99
order of the heart, 99
order, inherent vitality of, 161
organ formation and behavior, 107
organ, representational value of an, 141
"organelles", 55
organelles, plasma, 55
organic shapes, 148
organism, 82
organisms, cells as basic, 84
organisms, form-structure of, 138

organization, bisexual, 73
organization, cerebral, 14
Organographie Végétale, 161
organs of metabolism, 23
organs of speech, 134
organs, 51
organs, speech, 99
orientation, system of, 18
origins, 60
origins, animal, 134
origins, problems of, 60
ornamentation, devaluation of, 151
Orthoptera, 34
our construction set, 85
our human fate, 147
ova, 22
ovary, female organ, the fruitnode or, 162
oxygen, 62, 64

P

Paine, Robert, 117
paired limbs, 118
pairing-drive,32
pairs of limbs, 163
palatal arch, 102
palate, 111
paleontologists, 125, 133
paleontology, 55
Palermo, 160
paling, 28
Pamela, 115
"para-hominid", 133
past and future, 50
Pasteur's, Louis, 60, 61
pattern, color, 74
pattern-members, 83
patterns and designs, 25
patterns, richness of animals, 139
peacock's wheel, 142
"Peanuts", 104
Peking-man, Java man, 116
pelicans, 147
pelvic region, 136
perfecting of our rational relationship in the world, 132
period of pregnancy, 130
period, post-parturative, 107
period, uterine, 107
Perrault, 99
Perrault, C., 121
petals, blossom-leaves, the, 162
Peter, 115
pharynx, 101
phase of genius, 110
phenomena, 138, 171
phenomena, psychical, 48
phenomenon, form 74
phenotypes, 15
Philosophy, 123
physical chemistry, 58
physical-chemical analysis, 88
physical-chemical methods, 72
physics, 47
physics, classical, 55
physiological research, 149
physiology, 39, 56, 71
picture, *expressive display* of the, 140
pictures, creation of, 157
pigments, respiratory, 65
Pisanello, 150
"planetarium", 10, 11
plant and animal breeding, 138
plant life, zenith of, 170
plant metamorphosis, 160, 172
plants, annual, 162
plants, dicotyledonous, 161
plants, green, 64
plants, metamorphosis of flowering, 163
plants, metamorphosis of, 160
Plants, Metamorphosis of, 161
plants, origin of the flower in the higher, 163
plasma, 73, 79, 84
plasma, cell, 71
plasma, egg, 82
plasma, living, 83

plasmatic events, 13
plastic being, 24
play, 4
play, liberating, 154
Plessner, 65
Plessner, Helmuth, 136
Ploog, D., 123
plovers, 15
poetry, 159
Polanyi, Michael, 113,
Polanyi, M., 123
polarized light, 9
pollen vessels, 162, 163
pollinating insects or birds, 153
pollination, 169
pollinators, 153
polyps, 19
population genetics, 69
post-lacteal mass, 101
posture, upright, 130
pouched animals, 111
pouched animals, young of the, 111
pre-disposition, hereditary, 22
pre-dispostion, bisexual, 29
pre-form, 34
pre-formed seed, egg, and sperm, 60
"pre-hominid" process, 133
pre-human phase, 125
pre-Raphaelites, 158
pregivenness, 58
Premack, 115
Premack, D., 123, 128
Premack, David, 106
prepared field of possibilities, 14
prepared relationship, 15
presence sensed, 87
preservation, 98
prey and hunter, 41
prey, preordained as, 41
primal sounds, 110
primate, 118
primates, 99, 101, 111, 125, 135
primates, man-like, 114
primates, ontogenesis of the, 133
primates, social relationships between, 103
privileged organisms, 148
processes, fundamental, 59
processes, molecular and atomic, 51
propagation, 36
proteins, "immortality" of the, 54
protoplasm, 51, 66, 79
protozoa, 80
Providence, 147
psyche, 47, 171
psychic, 119
psychic-subjective, 50
psychology, animal, 48, 90
Ptolemaic man, 42
"Ptolemaic" system, 17
Ptolemaic world, 18
Ptolemaic, 17
Ptolemaicism of the spirit, 17
Ptolemaics, 42
puberty, 135, 170
Pygmie, 121

Q

qualities, 50, 88
qualities, realm of, 87
quantification, 50

R

radar, 8
radial, 24
rate of growth, fetal, 107
rationality of nature, 156
rats, 111
rays, ultraviolet, 62
reality, alienation from, 36
reality, non-dimensional, 1,25
reality, non-spatial, 28, 38
reality, relation to, 36
reality, two-dimensional, 25

realm of sympathy, supra-individual, 33
realm of the social world, 136
realm, proto-vital, 62
Reamur, 159
reason, 119
reckoning of time, biblical, 67
recombination, 70
redemption, 42
regeneration, 39
region of the poetic, overstepping of science into the, 139
reindeer, 142
relation between form and function, 148
relation to the world, acoustical, 108
relation, world, 58
relationship acoustical form of, 30
relationship, 12, 57
relationship, material, 57
relationship, pre-arranged, 40, 41, 42
relationship, world, 39
relationship-structures, 28
relationships, 25
relationships, active, 57
relationships, new world, 35
relationships, pre-arranged world-, 35
relationships, social, 56
religious, social and political fabric, 67
Rensch, H., 122
representation, self, 38
representational meaning, 142
research, 171
research, behavioral, 92
research, biochemical, 71
research, biological, 137
research, cell, 80
research, enviromental, 171, 172
research, functional, 140
research, hormone, 138
research, medical, 50
retarded maturity, 112
Revesz, 98, 119
Revesz, G., 121, 124
Rhesus Monkeys, 121
ribosomes, 55
Rilke, 156
rivalry-singing, 33
rivals, 32
robin world-,purpose-filled, 89
robin, 89, 90
robin, territory of the, 89
robins, 88
Rome, 160
roots, 161
Roux's, William, 49
Ruskin, John, 150

S

salamander, 150
saps, 168, 170
saps, rising and clarification of the, 164
Sarah, 106
sarcoplasma, 102
Sauer, G., 91
Scammon, Richard E., 129
Schaller, G. B., 122
Schaller, G., 104
Scheler, Max, 171
Schelver, 169
Schelver, Franz Jos., 169
Schneider, O., 121
Schneider, R., 102, 122
science, behavioral, 47, 87, 90
science, natural, 173
scrotum, 75, 76
sea anemone, 24, 25
sea anemones, 152
sea stars, 152
sea urchin, 24
sea urchins, 152
Sealab II, 115
season, migration, 91
secondary world of rational insight, 135

secret anastomosis, 170
seed, 169
segmented worms, 21
selection, 149
selection, sexual, 74
selection, theory of, 74
selection-value, 38
selective factors, 149
self, 25, 65
"self", 49, Intro., Part II
self-announcement, 30
self-construction, 39
self-description, 27
self-development, 49
self-differentiation, 70
self-gratification, 31
self-increase, 53
self-indentification, 26
self-manifestation, 27
self-metabolism, 49
self-presentation, 154
self-preservation, 16, 27, 65
self-preservation, 39
self-representation, 4, 15, 16, 154
semi-transparent beings, 24
sense impressions, 88
sensitivity, 49
sepal, cup-shaped leaf, the, 162
sex roles. 29
sexual alteration, 22
sexuality, 73, 74
shame, 28
shape, living, 147
shapes, "noble" animal, 150
shapes, closed, 150
shapes, privileged, 150
Sherrington, 160
shining opalescent, 23
shoot, heliotropic, blooming. 161
shoot, partial, 163
shoots, partial, 169
shrews, 118
shrilling, 31
signaling, 148
signs, "onomatopoeic", 98
silhouetted being of the shape in space, 150
sin, original, 41
singing, 31
singing, functionless, 4
skin, 27
skin, blood-vessels of the, 27, 28
sleep, 50
sloughing, 34
social activities, 142
social contact, 32, 106
social contact, Intro., Part III
social environment, 110
social factor, 34
social forms, origin of, 26
social group, 129
social incorporation, 135
social life, 113
social relations, 114
social relationship, 107
social relationships, 30, 128
social womb, 107
social womb, year in the, 132
soft palate, 100, 127
soical environment, 132
solar-system, Copernican, 42
somatic, 119
song, 74
song, adolescent, 91
song, functional, 91
song, functionless immature, 91
soul, 90, 91
"soul-life of plants", 48
sound production, 105
sound-organs, 30
sound-producing apparatus, human, 101
space and time, 90
space and time, transforming elevation of, 170
space, behavior in relation to, 91
special adaptation, 152
species indentification, 152
species, preservation of the, 143
species-characteristic sounds, 32

species-mutation, 39
species-preservation, 36, 39
species-preservation, 39
species-survival value, 33
species-transformation, 36
speech as co-determining our numbering, 113
speech group, 110
speech organs, ontogenesis of the, 107
speech possibility, Rubicon of, 117
speech using words, 132
speech, 98
speech, 98, 126, 128
speech, genealogy of our, 107
speech, human, 112, 119
speech-functions, 99
speeches, gesticulated, 128
speech, genesis of, 119
sperm formation, 75
sphere, individual, 91
spider's met, 142
spinal column, 135
spiritual analog, 147
spiritual law, 167
spiritual world, 147, 164
stamens, powdery-leafed, 162
Starck, D., 102, 122
starfish, 24
starling, 6, 9
Starlings, 5, 18
state, citizens of a, 81
state, service to the, 82
state, totalitarian, 82
statozutes, 21
stem-formation, two-dimensional, 167
Stenobothrus type, 31
stickleback, 88
stimulating social contact, 32
stormy petrels, 15
streamlined form, 148
strophe, 32
structure, antler, 142
structure, form, 139
structure, syntactical, 106
structure, the inner, 152
structures, living, 141
structures, nuclear, 84
structures, performance, 152
structures, plasma, 64
structures, plasmatic, 52
structures, serially repeated, 162
struggle for existence, 70, 149
subject, 58
subject-nature, 49, 57
subjectivity, 3
substances, proto-vital, 64
subtle psychical reactions, 28
succession of developmental phases, 35
Sullivan, Louis, 151
sun, being, 7
sun, organ, 7
sun-compass, 12
surface, opaque, 25
surface, potentialities of the, 28
survival value, 140
Survival, 3
survival, struggle for, 81
Swammerdam, 159
symbol-world, 171
symbolic interpretation, 147
symmetries, 23
symmetry bilateral, 23
sympathy, 35
"sympathy", 26
system, self-maintaining, 57
systems, inorganic, 57
systems, metabolic, Intro, Part II

T

tacit knowledge, 113
"taxomonic" value, 36
technology, human, 51
technology, occidental, 66
teeth, 101
telencephalization, 75

temporality, 59
tenacles, thickened ring of the, 152
tentacles, pairs of, 152
territory, 32
testes, descent of the, 75
testes, 75
testicle, 76
testicles, 142
testicles, decent of the, 74
"The Bumblebee and the Monks-hood", 166
the Church, 147
The Golden Mean, 150
The Metamorphosis of Plants, 165, 167, 168, 169
the, 157
theatrical contrivances, 166
thematic, 32
theoretical approach, 37
theory of evolution, 56, 134
theory of evolution, neo-Darwinian, 71
theory of evolution, special, 71
theory, evolutionary, 60, 66
thinking, physiological, 151
thinking, technologically oriented, 150
Thoma, Hans, 156, 158
thought, 128
throat sacs, 105
throat, 100
Thyreoarytaenoideus, 122
time, 4
time, experience of, 50
toad, 150
tongue, 100, 127
tongue, rear margin of, 100
tooth-formation, 102
tracheal orifice, 127
tradition, 97
tradition, group, 136
traditional values, 107
Traité de la Chenille, 159
trans-cellular nature, 83
transcendence, 140
transparency, 23
transparent body, 24
transparent creature, 28
trees, 161
Troll, 160
Tuffy, 115
Tursiops truncatus, 115
two syllable form, 110
two-fold potentiality, 34
tympanic membrane, 30
"types, metamorphosis of", 68
Tyson, 99
Tyson, E., 121

U

ultraviolet rays, ;62
unconcious, 22, 26
understanding, 119
unfolding of the rational elements, 135
ungulates, 129
unicellular, 80
unity of hidden potentialities, 167
unknown reality, 143
unstable transformation, 162
unsymmetrical, 23
upright posture, 128, 132, 135
uprightness of the body, 119
Urey, C. H., 62

V

vacuole-structures, 55
vague concupiscence, 170
value, systematic, 153
values, hierarchy of, 37
values, new assignment of, 143
van Lawick-Goodall, 122
van Lawick-Goodall, Jane, 104
variation, random, 69
variations, chance, inherited, 67
venom, 40

venom-fangs, 40, 41
vertebrates, 30, 75, 159
vessels, pollen, 168
viper, 40, 41
viral material, 47
visual apparatuses, 27
vocal chords, 102, 115
vocal space, 112
vocalization area, 100
Vogell, W., 122
von Humbolt, 68
Vowel Repertoire, 121
vowel-formation, 127

W

warbler's, 3, 8, 9
warbler-Ptolemaics, 17
warblers, 9, 10, 11, 12, 14, 18
warblers, garden, 8
warblers, hooded, 8-9
Washoe, 105, 106, 117
way of being, alien, 15
way of being, flyer's, 7
Weber, Hermann, 83
wedge-foot (*Heteropoda*), 23
Weimar, 159
whale, 113, 118, 130, 136
whale, baleen, 117
whale, sperm, 117
whales, 111, 118, 119, 127
whales, baleen, 114
whales, dentate, 114, 115, 117
what is most truly inward, 169
will to master, 59
Wind, J., 121
"wing" snails, (*Pteropoda*), 23
Woelfflin, Heinrich, 156, 157, 165
Wolff, C. Fr., 161
wonder-mongering, 60
word speech, 103, 116, 119
world experience, 35
world open, 136
world relation, 57, 119
world relation, poly-potential, 116
world, inorganic, 57
world, material, 47
world-formation, 35
world-related activity, 38
world-relation, 15, 38, 119, 137
world-relation, human, 134
world-relation, organic materials of a special, 137
world-relationship, 9, 12, 14, 16, 18, 28, 40
world-view, 18
writing, Chinese, 106

Y

Yerks, 105
young lions, 147

Z

zebra, 130
Zen Buddhist temples, 158
Zenker, W., 122
zoology, 48, 132

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18 439

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