EVOLUTION, SCIENCE and JUDAISM

A Jewish View

by

Isaac Joseph Brandstädter

EVOLUTION, SCIENCE AND JUDAISM

Isaac Joseph Brandstädter

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This special non-profit 2nd edition is being published under strict guidelines from the above-named now defunct author, by care of the author's daughter Aliza Drihem and his brother Aharon Brandstetter.

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IN MEMORY OF

the Author Isaac Joseph Brandstädter (1922 - 2010)
and his wife Edith Peri (1924 - 2005)

יצחק יוסף ברנדשטטר ז"ל
לעילוי נשמתו
ולעילוי נשמות
אשתו אדית פרי בת מלי ז"ל
והוריו
חיים בן משה מרדכי ז"ל
טויבה בת נחמיה הכהן ז"ל
ת.נ.צ.ב.ה.

The demise of the author, Isaac Joseph Brandstädter, has turned this book from the work of a lifetime into a pillar of remembrance. It is a unique pillar insofar as it sets out to bridge the gaps that are commonly believed to exist between science and Judaism.
We, Aliza Drihem and Aharon Brandstetter - the author's daughter and his brother - regard this book as the sum total of a lifetime dedicated to the pursuit of knowledge. Most of the varied fields of interest of this multi-talented intellectual, ranging from biology and physics, Judaism, history, through archeology - to classical music, are represented in this thin volume.
This is I. J. Brandstädter's legacy, a legacy of knowledge.

Due to the sad circumstances preceding this publication, I have taken on the task of editing the second edition of this book.
My sincere thanks are due to my wife, Judith, and son Yuval (M.D.) for their effective and indispensable assistance in processing and preparing the script for print. All this, subject to respectful adherence to the given text, punctuation and accentuations.
The rest will be up to our Graphics specialist, Mrs Vered Mark, and the Gestelit (Haifa) printing house chosen by our publisher Mr Eliezer Malin. To all of whom go my further thanks, for giving this book its (hopefully) attractive final form.

Aharon Brandstetter (Ph.D., ad-hoc editor)

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Foreword to the second edition

This second edition is a substantially enlarged version of the first, including a very few corrections. In part, the enlargement is due to material gathered in my further study of the sources, especially of publications that appeared, or came to my knowledge, after finishing the first version (May 2000).

It is intended for the general reader, supposed to have some elementary knowledge in biology and physics. With this, reading the book (with help of the appended Glossary and, possibly in addition, an English Dictionary) should present no difficulties.

The book contains an unusually great number of citations.

They serve the twofold purpose of presenting to the reader:

(a) a great number of statements coming from authoritative source, about facts of nature (in particular: of life)

(b) opinions of outstanding scientists about issues at stake; in particular, opinions that harmonize well with the general trend of the book.

To any person who inquires into the significance of his own life, knowledge about 'facts of life' to the widest possible extent will be helpful (not to say: necessary). Apart from the value of the knowledge itself, its virtue is to convince us of that old, but still valid truth: "I know that I do not know!" Or that other famous teaching: "The larger the sphere of our knowledge grows, so grows its interface with the unknown outside". Together with the elation that knowledge about the wonders of nature can convey, this knowledge may well be apt to show how wrong it is to throw overboard, thoughtlessly, human values sanctified by long tradition.

Therefore, the first-mentioned purpose has been given much weight, especially in the Notes (which were always used when the incorporation of their content in the main text would have interrupted its fluent discourse). With this, it should be clear, that the book is not meant to fulfill the function of a text book. What is said, should (hopefully) be correct; but by no means should it be complete.

The first question imposing itself in such inquiry (as mentioned) will be, of course, whether there is any significance at all, to our life in this universe; in a universe that may look simple to the simple man, yet is unfathomably vast and utterly mysterious to the thinker. To the latter, an answer in the negative or, at most, trivially in the positive (such as: if you got a lemon, make a lemon-squash of it), will naturally be upsetting and disappointing. Yet, materialists (i.e., atheists) can't help sticking to it. Here is the wellspring for the endeavors of many scientists-thinkers to challenge the prevailing materialistic theory about life's evolution during the ages. The present essay joins those endeavors.

It should be noted at the start, that the aim of this essay is to advance a *'Weltanschauung'* (view upon the world) that incorporates scientific facts or, at least, well-corroborated assumptions) in unison with a faith based on the Bible, (in particular its first book, Genesis, interpreted in a sensible, non-literal sense). This is in contrast to the endeavors of a 'Scientific Creationism', rather strongly expanding overseas in the last years. This is so insidious a movement that serious biologists feel a need to repost to it. Thus, the renowned evolutionist Douglas J. Futuyma, author of the widely accepted textbook "Evolutionary Biology" (several editions, 1979-1998, of which we shaIl have occasion to quote a few times), found it in place to devote a special book ("Science on Trial", 1995), to the end of countering that kind of '*Creationism*'.

The harmonizing opinions of eminent scientists as presented in this book are well-suited (in my humble opinion) to demonstrate, that an attempt to develop such a (so-called) 'Scientific Creationism' along the lines followed here, is not without a sound basis.

Contemporary science, we try to show here, already yields such a basis. The advances of science that can, no doubt, be expected to come in the future, hold promise of being of nature to further consolidate it.

Jerusalem, April 2003

the author I.J.B.

Preface

The theory of evolution by natural selection was first clearly formulated by Charles Darwin in his classic "On the origin of species" (1859). In conjunction with modifications and supplements introduced later by so-called "neo-Darwinists", "ultra-Darwinists" , etc., it is still endorsed by many (if not most) scientists.

Classical Darwinism proclaims, that the existence of life, the immense variety of species (both extinct and presently living), and the richness of forms and functions they display, is most readily understood with the aid of the following two concepts:

(1) "Descent with modification": Offspring are normally slightly different from either parent. This random variation is produced, in particular (as we today know), by random mutations occurring in the DNA, contained in the chromosomes and carrying the genetic code. The changes in the offspring in respect to parents that are engendered by these mutations are inheritable, because the probability that another change will occur, in the following generation, at exactly the same place (in the often extremely elongated chromosomes) where the prior change occurred, is exceedingly small (as will be seen later).

(2) "Natural selection": nature ultimately 'selects', out of any generation, those variations, which make their bearers more 'fitted' for life. This process of natural selection takes place automatically, because the chances, either of survival or of reproductive success, or both, of the individuals with those 'fitter' variations, are increased. It is this difference in fitness which drives the evolution of a species from a more primitive to a higher form. Over many generations, the types with the enhanced fitness will predominate in the population.

According to Darwinism, -- and this is a much stronger, and therefore much more questionable statement, -- natural selection, in the long run, produces 'speciation' (birth of new species): in general a "higher" species out of a "lower" one. Speciation is still today a controversial issue just as are many other issues in the theory) even among sworn materialistic Darwinists.

The belief in the truth of that theory has induced many people to deny creation of the world, and of life, by a Divine Creator; they try to explain all presently existing life as being the outcome of 'blind' physico-chemical processes. According to their theory, the evolution of life started, some three to four billion years ago, with the appearance of very primitive life forms (archaea and bacteria). These primitive organisms came into being (via some hypothetical, unknown common ancestor, dubbed 'progenote') from inanimate matter, by way of happenstance chemical combinations. The chain of those combinations of inanimate molecules can, in principle at least, be traced back in time onto interactions between the most elementary particles. These latter, however, came mysteriously into existence, out of nothing ('ex nihilo'), in a tremendous cosmic event, commonly called the 'Big Bang'. "Almost everyone now believes that the universe, and time itself, had a beginning at the big bang" (Stephen Hawking, 1996).

The present essay tries:

(i) to give a short, fairly updated account of some of the more important developments in the field of evolutionary theory (or, as the philosopher of biology Elliott Sober calls it more correctly: "The historical hypothesis of evolution");

(ii) to show that our understanding of the world is necessarily based on beliefs, irrespective of whether the pondering mind is guided by religious principles or not;

(iii) to make the point, on the basis of scientific findings and of the well-accepted scientific guiding principle of parsimony ("Ockham's razor" [1]), that the beliefs of non-religious people are much less plausible than belief in the intelligent design of the world by a supernatural Creator; and finally,

(iv) to show that correspondences exist between Jewish faith and advanced concepts in modern physics; and that views expressed by eminent modern scientists harmonize very well with those of authoritative Jewish scholars.

Elliott Sober, by no means a defender of Creationism, says about Darwinism, in his book "Philosophy of Biology": "It is a sound working hypothesis (**which may just possibly turn out to be mistaken**) that living things are nothing but structured chunks of matter" (Sober 1993, p.24; my emphasis). And: “Perhaps one day Creationism will be formulated in such a way that the auxiliary assumptions it adopts [such as the existence of a “elan vital” - or a soul] are independently supported” (l.c., p.52). Coming from the pen of a renowned thinker, atheist, such uttering should not be ignored. Modern evolutionists postulate the existence of a “deeper cognitive principle”, as well as a “highly abstract esthetic rule”, guiding the behavior of even such primitive animals as birds and fishes. They moreover believe that such principle, and rule, had a significant role already at very early stages of evolution. Hence, people who lent credence to a purely materialistic theory of evolution may well feel induced to think it over again.

Note to the preface

"Ockham's razor" is the epithet for a method used for the advancement of science. Dating back to the 14th-century theologian William of Ockham, it stipulates that premises, or assumptions, that had once been accepted rightly as means for understanding nature (or philosophical issues), should be dismissed as soon as that becomes feasible (i. e.: as understanding can be attained without them.)

Two famous examples from the history of science are:

1. The *phlogiston*. Since Plato (at least), combustion and oxidation were believed to consist in the escape of some medium of awkward properties (sometimes of negative weight!) from the burning (resp. oxidizing) material. This imaginary substance was later called phlogiston (after the Greek word for 'burning'), by the medieval German chemist Georg E. Stahl.

The idea of the *phlogiston* prevailed until well into the eighteenth century. The great intellectual genius Joseph Priestley, among other things a chemist, discoverer of several gases (including oxygen, the agent of combustion and oxidation), adhered to the idea until his death, in 1804, Yet, his contemporary, the great French chemist Antoine L. Lavoisier, (while using Priestley's results!), advanced around 1775 his 'antiphlogistic theory', establishing the atmospheric gas oxygen as the sole entertainer of combustion.

Ockham's razor had done good work, here. Lavoisier became the father of modern chemistry. In appreciation of his merits, (and for being accused of alleged blackmailing, in former years) he was sentenced to death and executed by the Liberté enthusiasts, in 1794.

2. The *'ether'*. Supposed to be an ideally elastic medium pervading all of space, the (imagined!) ether should be the carrier of electromagnetic radiation (e.g., light). Einstein, in giving shape to his twofold (special and general) theory of Relativity, 'shaved' the ether away, as an unnecessary appurtenance. (When still used, nowadays, the term has a different meaning. On this, something will be said in chapter **IX**).

Chapter 1. In the wake of Darwin

A theory in turmoil

Let us note from the start, that the theory of evolution has by no means attained a state of maturity; as a comprehensive theory, it is still in a state of flow. Its final form is not yet definitively shaped. Firstly, there persist quite a number of internal controversies (which sometimes take the form of harsh polemic; "turmoil from within"). Secondly, new ideas, amending current theory, come up all the time. And even: "New theories of evolution appear nearly every year" (Lima-de-Faria 1988).[1] "Molecular theory of evolution is still in status nascendi" (Küppers 1985, Preface). A fairly updated account of this fluid state has been given by Marc Ridley (Ridley 1993, 1996). The turmoil is rather increasing all the time. "In fact", it is said in 1997, "there is currently more controversy regarding the mechanisms of evolution than at any time in the early years ... " (Carroll 1997, p.2).

One is also struck by the ubiquity, in the relevant literature, of expressions such as: "presumably", "may be due to", "could be", "is believed to be", etc., in place of firm statements, as one is normally used to, in the exact sciences.

The driving force behind the endeavor to structure a comprehensive theory of evolution of the living world, from its very beginnings on, without having recourse to the concept of creation by a supernatural Creator is, of course, the natural desire of the researcher to try to explain physical phenomena in rational terms. Scientists, in their eagerness to be able to explain everything, are reluctant to accept a solution in which the explanation is implicit. "… the supernatural Creator is not explanatory. The problem is to explain the existence of adaptation in the world; but the supernatural Creator already possesses this property. The thing we want to explain has been built into the explanation" (Ridley 1993, p. 3 23). ('Adaptation', in this context, means the property, either of the body of a living thing as a whole, or of its various parts separately, of **being adapted to perform their respective functions,** under the given life conditions in a given environment. For example, the bird's wings, replacing forelegs, is adapted to flight). [2]

Such an approach is a perfectly legitimate one in scientific methodology. It is, of course, one of the main objectives of science to explain to our analyzing and synthesizing mind the natural phenomena brought to our consciousness by our senses, as well as the causal relationships interconnecting them. However, this does not imply that those explanatory endeavors will necessarily yield the truth. Moreover, a scientist, especially in the field in question, can hardly adopt a completely neutral position. Stephen Jay Gould, presumably the most prominent paleontologist-evolutionist of our days, declares: "I am, as several other essays emphasize, an advocate of the position that science is not an objective, truth-directed machine, but a quintessentially human activity, affected by passions, hopes, and cultural biases." (Gould 1980; p.225). And with the citation of P.B. Medawar: "Innocent, unbiased observation is a myth", Eldredge and Gould introduce their iconoclastic new concept of. 'Punctuated Equilibrium (Eldredge-Gould 1972, p.84; we return to it in a moment).

Understandably, philosophers, to whom the search for truth is a central concern, seem more ready than scientists to admit the existence of the Creator.

One criticism which has repeatedly been directed against evolutionary theory is, that it is **too good** a theory since, by appropriately modeling it, it will explain any biological phenomenon whatsoever. Consequently, the theory cannot be invalidated; it is not '*falsifiable*'. Not being conform to Popper's criterion of falsifiability [3], it cannot be regarded a valid scientific theory.

Be that as it may, a 'theory' (falsifiable or not), whatever plausible explanations it may yield, **is not necessarily the truth**. This statement is of such general validity, that it should everlastingly be kept in mind. Karl Popper, the eminent philosopher of Science, has expressed this in most rigorous terms: To prove a theory being true is an impossible task; only 'satisfactoriness' can be assessed (see [3]). This is only all too often ignored in modern scientific writings. Justifications for this (expressed or tacit) attitude (of omission of any reservation), are readily at hand (such as, e.g., "overwhelming evidence"). Therefore, let us have a closer look on some of the more relevant aspects pertaining to our subject-matter.

Works published by a number of distinguished scientists in the last few decades lend strong support to the refutation of the Darwinian “dogma”, that **heritable variability** (engendered by genetic mutations) and **natural selection** were the main (or even: the only) factors in the evolution of the species. These writers stress, that evolution of life on earth **has proceeded in an orderly manner** from its earliest stages on; a fact that is incompatible with the idea that chanceful stochastic [see Glossary] mutations were a decisive factor in driving the evolution of life from its modest origins to its present wealth of, as a rule, perfectly well adapted living species, (the almost infinitely many unsuited variations having been “filtered out”, imperceptibly, by natural selection). We shall endeavor to expose some of the salient traits of their teachings.

According to classical Darwinism, life on earth emerged in a “primeval ocean (or pond)”. It evolved out of inanimate “pre-biotic” molecules, formed through random chemical synthesis from simpler organic molecules present in its waters. This was “spontaneous generation”, a kind of coming into being of living things that was believed by scientists, until near modern times, to take place currently in lower animals (e.g. lice). This thesis of “generatio spontanis” has been disproved in a most general way for all living beings, both extinct and presently living. [4] But once, (so the theory), perhaps really only once, it happened! Pure chance brought it about, that a molecule endowed with the very peculiar feature of ***self-replication*** was formed, quite accidently, in the course of said synthesis. (Self-replication, a very peculiar kind of chemical reaction, evidently is a rudimentary form of reproduction). Sir Francis Crick (the co-discoverer of the structure of the DNA molecule), from a typically atheistic standpoint, called this unique formation of such a molecule, carrying the ‘genetic information’ apt to reproduce itself, a “frozen *accident*”. That is to say: The molecule was once formed (in the “primordial soup” of the ocean, or pond) by a purely accidental chemical reaction, one of utmost low probability of occurrence; but once formed, its property of self-replication secured its proliferation and perpetuation. This accidental happening (so Crick, and modern Darwinists, in general) was enough to initiate a very long and complicated chain of processes until, in the course of time, a cell, endowed with the prerequisite properties of a living thing, had evolved. From this cell (or at most a few such kinds of cells) all living beings, both single- and multicellular, extinct and presently living, evolved in the course of some three to four billion years. Three processes contributed to this amazing deployment of forms of life as witnessed by us today:

(i) spontaneous self-organisation (Crick's purported 'frozen accident' is only a first example thereof; two modern models will be outlined in the sequel). [5]

(ii) completely random and chanceful mutations, (comprising all kinds of genetic change, including. recombination between chromosomes), occurring in the genetic material of an individual. When offspring is produced , the genetic changes may be transmitted.[6]

(iii) natural selection (explained in the preface).

There is no intelligent guidance in all this immense and astounding process of life's unfolding. So Darwin. A first breach in this edifice had already been made by Darwin's contemporary, Sir Francis Galton. Darwin had insisted that adaptation must necessarily have proceeded in minute, almost imperceptible steps. In Darwin's own words: "If it could be demonstrated that any complex organ existed which would not possibly have been formed by numerous successive slight modifications, my **theory would absolutely break down**." (cited by Ridley 1993, p.326; my emphasis)

Galton objected that such small variations might rather revert, through the generations, to their original forms. In Galton's model, evolution can be likened to the movements of a stone of polyhedral form. When only slightly disturbed from its rest-position on anyone of its polyhedral facets, the stone will return to its original position, when released. A rather stronger force will be required for having it "tumbling over into a stable position of rest, on another facet" (Galton 1889, p.27). Galton's thesis had been rejected, as a general evolutionary rule, by Alfred Russel Wallace, an independent proponent of the theory of evolution and later co-worker with Darwin. But, remarkably enough, it has been favored again by S.J Gould (mentioned above). In one of his recent books, he says: "The polyhedral stone will not move at all, unless natural selection pushes hard" (Gould 1993, p.384). In the metaphor of the polyhedral stone, the facets represent internal

constraints in the genetic constitution of an organism; these constraints oppose the fixation of the small variations postulated by Darwin.

This picture of a polyhedral stone espouses well the (by now well-known) thesis of 'punctuated equilibrium', advanced by S.J. Gould and N. Eldredge (Eldredge-Gould 1972). These two paleontologists conceive of evolution as having proceeded in rather abrupt evolutionary changes, called 'saltations', occurring during relatively short periods of time. Saltations are believed to be separated by long periods of 'stasis' (i.e. of no substantial change).

This model is further confirmed by Carroll (1997), as concerns macro evolution (i.e., the emergence of the major taxa). It is all the more remarkable, and thought-provoking, that in contradistinction to the gradual progression characteristic of microevolution (i.e., within species), "major lineages appear suddenly in the fossil record and then persist for long periods of time within the same structural and adaptive framework" (Carroll 1997, p.8). This fact is at the origin of the rather paradoxical-sounding assumption that evolution occurs much more rapidly between groups than within groups" (l.c., p.2).

While thus supporting Gould-Eldredge's view, Carroll expresses much skepticism about the proposed mechanisms, leading to the amazing stability as observed. For this reason, perhaps, he finds it appropriate to quote the opinion of a resolute antagonist: "From a genetic point of view, the hypothesis that Eldredge & Gould (1972) proposed to explain the patterns claimed for the fossil record **appears untenable**" (Futuyma 1989, p.558; my emphasis). When we shall come to speak of the factual rates of genetic change (in chapter IV.), we shall see how much Futuyma's contention is justified.

Depew & Weber (of whom we shall talk later-on) think that "Genomic constraints would presumably also explain the persistence of Bauplaene ... , and, hence, the stasis in the fossil record." (It is common practice in the relevant literature to denote the purposeful body constitution of living things by the cited German term, meaning literally: 'building plans'; i.e.: blueprints.) (Depew-Weber 1988; p.327)

In conformity therewith, Gould's suggestion is, that about 99% of the history of a species was passed in stasis. (1982; cited by Carroll 1997, p.28).

The model of the polyhedral stone, then, already admits the existence of constraints which are of nature to assure the species' stability ; this latter can be disturbed only by a "hard push". (Of the astounding stability, both of species as a whole and of their functional parts in particular, we shall come to speak below).

The nature of such hard pushes, strong enough to overcome the constraints, has not been specified in said discussions. One may wonder about them. 'Drastic changes in environmental conditions', this is the commonly given, but rather vague, argument. For one, it does not explain **how** the adaptation to the new conditions comes about. Moreover, we shall come across cases of rapid adaptation to environmental changes, though not drastic; they were, so-to-say, 'elected' by the species themselves.

John H. Gillespie, in his very interesting book: "The causes of molecular evolution", says in the preface: "Naturally occurring genetic variation is an enigma .... so easy to observe and so hard to understand." Gillespie confirms a statement made already earlier (in 1971) by Motoo Kimura (the founder of the important branch of 'Neutral Evolution') : "the variations in evolutionary rates among highly evolved animals are larger than expected by chance" (Gillespie 1994, p.110).[7]

More particularly, Gillespie draws the attention to some remarkable cases of speeded-up molecular evolution which, surprisingly, occurred precisely when environmental conditions necessitated it. In the examples reported by him, the environmental changes can hardly be termed 'drastic'.[8] Thus, Gillespie states: "We do not know the forces responsible for this evolution" (l.c., p.107).

In any case, it can be said that Galton-Gould's thesis already contradicted Darwin's **'gradualism'** (i.e.: smooth evolution, throughout, in small, almost imperceptible steps), a principle that is also fully endorsed by the neo-Darwinists.

The leading anatomist Rupert Riedl has firmly established the fact, that "standard parts" of living organisms (e.g. muscle fibers, hairs, cilia, even organic macromolecules), once evolved, got "fixated" (i.e. they do not any more undergo evolutionary change) for immense periods of time (Riedl, 1978).

Let me quote from Riedl some outstanding examples:

1. The muscle attachment of the eye is almost identical in sharks and in man. It "has been preserved **independently and unchanged** for 400,000,000 years" (p.138; my emphasis).

For a better understanding of this statement: The fossil remains of **one particular** species of sharks (it has got the nice name: Heterodontus Portjacksonis) are traced back that long span of 400 million years (compare Grassé's statement, below, which dates back "**some** species of sharks" more than 100 million years). This particular shark species is still extant today; it is a so-called ***'living fossil'***. Its eye-muscle attachment has remained "unchanged" since. Moreover: seen that, according to the conventional phylo-genetic tree, the line of descent of modern man separated from that of sharks still earlier (than the stated period of 400 million years), it follows that the almost identical muscle-attachment must have either evolved or, at least, preserved "independently". This is, then, a remarkable case of either 'convergent', or 'parallel', evolution (to be spoken of later on), in fish and man. [9]

2. The cilium is one of the most archaic, yet widespread organelles, from the cilia, or the flagella, of bacteria and single-celled organisms, to the human eye cilia. It has "certainly existed for a billion years." The constancy of its 'Bauplan' "is a **super-regularity of astronomical dimensions**", represented by a *'super-determinacy'* of 10^{18}. (p.107; my emphasis). Riedl considers it "undoubtedly one of the most astounding phenomena of life" (p.107).

3. "Certain giant molecules, like '*cytochrome* c', are fixated in the whole organic world" (p.113). [several other giant molecules, proteins that are even more stable than the protein cytochrome c exist. For example, the rate of evolutionary change of the protein Histone IV is fifty times slower than that of cytochrome c (Kimura 1979; p.100).]

Beyond this, Kimura tells us, that "we know many features of this age [500 million years], yet still widespread at present, among living organisms. . .. , these systems of maximal fixation are realized abundantly in evolution" (l.c., pp.131, 140).

We are facing here a "universal principle of identical, standardized replication". This extreme stability presents a real challenge to the lesson evolutionists have drawn from Shannon's information theory, which teaches: Information, (including such as stored in the genome) necessarily suffers deterioration in the course of time. (We shall return to this important issue in Chapter IV.).

As mentioned above, the hypothesis that life emerged on earth thanks to extremely rare chance events, was strongly challenged by number of scientists. Kenyon & Steinman (1969), in their book with the revealing title "Biochemical Predestination", declare, that "such hypotheses are contrary to most of the available evidence" (p.31). These authors reject the contention that highly improbable stochastic events were at the base of life's evolution. Rather, "**Non-random highly constrained** chemical processes were probably involved in the origin of life". Citing results of much of their own experimental research, as well as other investigators', they come to the conclusion that:

"From all that has been discussed ... , it would appear that the conditions and compounds found on the primitive Earth had a **built-in predisposition**, which ultimately led to the development of biological systems as we know them today" (p.254 my emphasis). Natural selection, according to these authors, takes over only at a certain, sufficiently advanced stage of biogenesis in those systems.

Meanwhile, we note the concept of a built-in predisposition "of the primitive Earth", (which surely can only mean: of the [created] matter in the state it had reached in primitive earth). Such **predisposition of [created] matter** harmonizes singularly well with a main theme to be developed in this essay.

Another proponent of a theory that is not based on the occurrence of chanceful events, is Bernd O. Küppers (mentioned above, a disciple of the famous Manfred Eigen). Küppers, at variance with the former authors, believes that natural selection began to operate from the start of biogenesis on, i.e., from the appearance of "bio-organic" molecules on early earth. He begins with demonstrating that the odds, for the genetic material of one of the most primitive living beings (E.coli bacteria) to have arranged itself in the correct order by pure chance, are practically nil, (namely: one in n; where n is the absolutely unimaginably huge number: ten to the millionth potence~ i.e. a one followed by a million zeroes!). Therefrom, Küppers argues against Nobel laureate Jacques Monod, a strong promoter of the chance argument, notably in· his much read book "Chance and Necessity" (1972). To be sure, he presumes to claim, that "Monod's hypothesis is unscientific"! (p.41) [10]

Küppers then tries to demonstrate that evolution by natural selection begins already at the level of those macromolecules which determined the character of the living cell (called: "the atom of life"). He states: " ... we need a selection mechanism for the origin of the [genetic] information which is then to be used for the construction of complex biological systems." Such selection of one molecular species, out of a mess of "pre-biotic" macromolecules, is a chemical process (exemplified in Küpper's book) of spontaneous self-organization of the molecule; then, of self-replication, and finally: of shift of the system to an equilibrium-point, where the other present, "competing" molecules are eliminated. Of course, we are requested to believe that 'almighty evolution' managed to lend a selective advantage **precisely to those (inanimate) macromolecules which are needed**, **at a much later stage, in living beings!**

Anticipating the objection that selection can only be a typical and exclusive property of living systems, Küppers comments: "This objection [that we need a selection mechanism for lifeless molecules] seems to steer us into a cul-de-sac, unless we choose after all to **revert to a creation-story** or to an existentialist concept of chance. **Avoiding the latter course**, ..." (p.34; my emphasis), in summary, Küppers rejects **both** creation **and** evolution by chance. Natural selection, however, he deems indispensable, for evolution to have occurred as we "know" it has.

This belief is not shared by all evolutionists, of course. The modern trend in the theory of evolution is more and more in the direction of, at least to a major part, canalized evolution. Natural selection is invoked only when everything else fails. Beyond this, there are scientists who resolutely deny the possibility that evolution might have 'worked' by the action of physico-chemical laws alone.

There is, first of all, the very interesting theory of Stuart A. Kauffman. In his book "The Origins of Order" (Kauffman 1993), he expounds his thesis, that the emergence of life out of inanimate matter, rather than being due to a very long sequence of improbable chance events, follows **quite naturally** from the **inherent properties** of complex physico-chemical systems. Life **'integrated itself'** by means of a "collective emergence of autocatalytic sets of catalytic polymers" in a primeval ocean. Such collective synthesis (in place of Crick's "accident"!) is believed by Kauffman to take place quite naturally in "sufficiently complex sets of polymer catalysts and organic molecules", once these reach a *supra-critical state*. Based on the results of extensive computations, Kauffman contends that under favorable conditions, a system of polymers may become collectively self-reproducing. Thus, life is seen by him as "crystallized", out of a sufficiently complex system of catalytic polymer molecules, into a "***collective self-reproducing metabolism***". Chemical interaction, taking place in such a complex system containing catalytic polymers, is expected by Kauffman to lead, by a process of collective *reflexive autocatalysis*, to self-replication, coupled with a "*coordinated web of metabolism*" (p. 295). "**Life began whole and integrated**", Kauffman proclaims (p.285; my emphasis).

Such a self-reproducing molecular system, even when still lacking a genome, should be able to evolve by inheritable variation and adaptation (two criteria for Darwinian evolution). Replication by way of a template (as in the transcription process of DNA and RNA) is not required, he contends, for the perpetuation of those (molecular) species. As for natural selection, Kauffman is not denying its playing **some** role in evolution. Its role, however, is merely of "purifying", of eliminating the unsuited. But "selection has not struggled alone" (p. 642). "**It** [evolution] **is *emergent order honored and honed by selection*** " (l.c., p. 644; my emphasis).

Kauffman's thesis is a serious attempt to explain the manifest tendency prevailing in the biosphere, to the ever-increasing ordering of matter. It **is an anti-chance thesis**. Selection plays a minor role only. It is not a creative force. Its action is to eliminate the unsuccessful, the 'unfit'. Natural selection is merely "honing evolution".

Bennett (1997) concurs, with his contention that "there is no evidence that it [natural selection] accumulates over longer periods of time to bring about speciation in the Darwinian sense." (p.175).

Kauffman admits, that his "provocative hypothesis... derives from a mathematical theory, which is **silent on the deepest issues**" (p. 286; my emphasis) [11]. We may well ask, what kind of evolution can be expected, at the later stages of evolution, on the basis of such a theory. How could evolution possibly have transcended in such magnificent way, as we see with our eyes, this first stage envisaged by Kauffman; a stage that consists solely in the proliferation of those chemical compounds which are optimally adapted to self-replication in their respective environments, and the ensuing repression of the less adapted compounds by shortage of the necessary chemical 'food'?

Bold as this hypothesis of the 'life-creating' capabilities of "collectively autocatalytic polymer systems" no doubt is, it is claimed by Kauffman to be testable. Should it be found correct, it would represent a major deviation from all of the presently defended Darwinian theories. In particular, it would establish a firm basis for the belief in a deterministically "pre-programmed" evolution of the organic out of the in-organic, agreeing in this respect with the claim of Lima-de-Faria (to follow), and also with the Jewish view advocated for in this essay.

We may note that, if Kauffman, as well as Grassé (see below) and Eldredge & Gould [12] dovetail with respect to the role played by natural selection (as characterized above), this would correspond to the Jewish principle stating, that the usual course of events in the world is governed by "the way nature behaves" (בדרך הטבע). Even more relevant to our theme: Kauffman's thesis conceives evolution, (at least in its early phase), as a **deterministic** natural process, expected to take place on the basis of the physico-chemical laws of nature.

Could it not be, that not only the early phase, but the whole of evolutionary history was governed by laws of nature that determined its course?

Before delving deeper for an answer, I would like to draw attention to the most remarkable and innovative theory of the renowned geneticist A. Lima-de-Faria. In his book "Evolution without selection" (Lima-de-Faria 1988), he exposes in detail his concept of "*autoevolution*", supporting it by a wealth of findings in nature and of results of experimental research. According to his theory, evolution proceeded in three stages, starting from the very beginnings of the Universe's existence. The first stage was the evolution of the elementary particles, from the most basic ones known to us presently (quarks, electrons, neutrinos, etc.), to the main building-stones of galaxies (protons, neutrons, ions and atoms). The second stage (taking place on earth and other cooled-down heavenly bodies), was the formation of crusts, rocks, crystals, water-bodies, etc. etc. The third stage was the emergence of life, in all of its richness of forms and functions.

The capital point in Lima-de-Faria's thesis is that, just as it lies in the nature of things that the second stage evolved necessarily from the first, so the third evolved necessarily from the second. De-Faria finds, and, as said, amply documents, that *form and function*, prevailing in the realm of life, are present already in non-living structures found on earth, especially in crystals. Evolution is "***canalized***".

Natural selection, Lima-de-Faria says, plays **no role whatsoever**, in evolution. He goes so far as to proclaim: "No selection; selection is a term that must be banished from evolution, if its mechanism is to be understood in strict physico-chemical terms". "... it cannot be considered to be the mechanism of the material process of evolution." And that: "**Order prevails at every evolutionary level**" (pp. 312-13; my emphasis).

Leaving aside the controversy on the precise role natural selection played in evolution, Lima-de-Faria's thesis opens a new horizon: It says, in essence, that at the very moment of its coming into existence, be it by a "Big Bang", as the story runs today (it is found acceptable by Jewish-religious thinkers) or along any other cosmogonist model, the nascent universe was already bearing in its womb the whole future development, up to this day and forever, in a way completely determined by the laws of nature. We can state this in our manner: When G-d created the world, He created, in potency, all of its further evolution. May it not be, that this is the deeper sense of the words: אשר ברא אלוהים לעשות (בראשית ב' ג') (literally: "which G-d created, in order to do [further-on]" (Genesis. 2,3))?

"*Canalized evolution*" is an expression of G-d's Omnipotence and Omniscience, in complete accord with Jewish faith. Being relevant to ponderable matter only, it does not involve any problem connected with a belief in free will. The latter poses a well-known problem; Yet, before turning to such spiritual matters, let us not overlook the fact that there are eminent scientists who deny evolution through the action of physicochemical laws alone, from the start.

Pierre P. Grassé, eminent French biologist, gathered "Evidence for a new theory of transformation" (Grassé 1977). Like Lima-de-Faria, Grassé says about evolution: "...it proceeds in a continuous orderly manner. It does not result from random incoherent variation" (p.9). Natural selection had at most a minor role, (if any). Grassé is definite on the point, that "**evolution is oriented**" (p. 55, and throughout his book; my emphasis). "...the living world has evolved, and perpetuates itself, in an orderly manner". After more than fifty years of research, Grassé states: "Life results from the adjunction of complementary systems to some determined material systems [governing dead matter]" (p.3). These complementary systems endow living creatures with intelligence. "... any living being possesses an enormous amount of "intelligence", called 'information' today; but it is still the same thing" (p.2). We shall return to this very important point in chapters IV.- V., keeping in mind that, here, "information" refers, preferentially, to the genome, i.e., to the totality of genetic information of an organism. Grassé's deep knowledge of the living world lets him clearly recognize, that oriented evolution derives from "an intrinsic property of all living creatures": It is an "immanent **biological finality** [goal striving], which is **strictly channeled and utterly opposed to chance.**" (p. 166; my emphasis). This *finality* reveals itself, quite universally, in the fossil record: the different lines of descent radiating (emanating) from a common stock (in the remote past) always show, to a greater or lesser extent, their innate propensity to achieve, gradually and steadily, the form or type (called "*idiomorphon*") they have attained at present. Otherwise said, we do not find what could be called "straggling"; let alone the fact that **we never find a reversal of direction** in evolution (this is called 'Dollo's law'). Here, we have a clear expression of orientation in evolution.

Evolution is traceable solely through the fossil record; ".. these [fossil forms] are the only forms in which evolution has materialized" (p.7). And this record is far from being well-known; whence, the hypothetical nature of the theory: "From the almost total absence of fossil evidence relative to the origin of the phyla [the major subdivisions of the kingdoms], it follows that any explanation of the mechanism in the creative evolution of the fundamental structural plans is heavily burdened with hypotheses" (p.31) [13]. And one of his conclusions is, that the "problems are very far beyond the means of present-day science. Interpretations and explanations advanced by whomever it may be, can only be partial and tentative" (p. 243).

Grassé rejects the Darwinian thesis of variation-based evolution: "**To vary and to evolve are two different things**" (p.6; my emphasis). Although there is more than ample evidence for variation within a given species, we cannot conclude there-from that variation also leads to the birth of new species, with characters different from the ancestral ones; far less, that it happened in such a general way that all modern species evolved from one (or at most a few) living form(s), as depicted by evolutionists, i.e. in the fashion of a phylo-genetic "tree" (or "bush"). Proof thereof is the existence of a considerable number of living species called "***living fossils***". So called, because they have persisted during many Myrs (short for 'million years'), without major morphological changes. These "*panchronic species* ... , … which for millions or even billions of years have been mutating without any noteworthy change", abound on earth (p.202). Examples are: sharks ("some of them for more than 100 Myrs"), Opossums ("for 70 Myrs"), insects (including cockroaches) "unchanged since the Permian [~250 Myrs BP (before present)], yet they have undergone as many mutations as Drosophila [the fruit fly; extensively used by researchers in genetic studies]"; but these many mutations did not prevent them from guarding their species identity. And, last not least, the bacteria: they "have remained bacteria for the past two or three billion years, ... vary extensively and in the greatest disorder, but they go around in circles" (p.60), without loosing their 'species identity'.

And Grassé asks: "What is the use of their unceasing mutations, if they do not change?" We could add many more examples. (See 'Further readings', at end of chapter) [14].

Further questions arise: Grassé points out the remarkable fact that, in quite a number of evolutionary descent lines one finds the ancestral form (the "stock form") still thriving today, side by side with their modified descendants; the former, sometimes, being even more resistant to food and water shortage than the latter (p. 176).

Cases of this kind are found everywhere. We may ask: How has a 'blind' process of natural selection possibly produced such dichotomy (division into two sharply differing kinds): the pan-chronic "fossil" forms, and their modern descendents; both thriving today, while no intermediate stages have remained extant?

Since the time Grassé wrote this, his argument (that variation does not imply speciation) has undergone a striking confirmation, in the domain of the most ancient living beings, the '*archaea*' (formerly called *archaeobacteria)*. Belonging to the Superkingdom '*prokaryotes*', they have come to be thoroughly investigated during the last two or three decades.[14] They also, (like the higher 'living fossils', we spoke of), still thrive today; yet we find their most ancient fossil remains well before the proterozoic eon (which extends from 2.5, to 0.5 Byrs, BP). That is: these 'microfossils' are dated, (by the age of the strata in which they are found), as having lived from about 3.5 to 2.5 Byrs BP, on the geological time scale. ('Byr' is short for 'billion years'; 'BP' for 'before present'). [15]

With this, archaea are considered to be extant organisms whose ancestors sat at (or very near to) the very root of the phylo-genetic tree. Again, we have that super-stability so exaltedly emphasized by Riedl and Grassé, yet here encompassing a much longer time span: during the quasi-total time of life on earth [16].

In face of this impressive, outstanding super-stability (and in spite of it!), S.J. Gould, when expounding how primitive living things have 'engendered' creatures of higher forms (thanks to "Lady Luck"s graces to Evolution!), expresses this in his manner: "But the reshuffling and subsequent evolution of DNA [of the prokaryotes, such as archaea] have not simply recycled the original products; **they have produced wonders**" (Gould 1980, p.226; my emphasis).

The question imposes itself: how did these wonders come about? I can see only one sensible answer: they are **'Wonders of Creation'**! In chapter X. we shall expand on the intimate connection between sub-microscopic processes and creation. The *'reshuffling*' of the building-stones of DNA (i.e., the atoms composing it) is a submicroscopic process. It concerns, in the last instance, relatively small groups of atoms (namely: the purine and pyrimidine base residues that form, chainlike, the molecule of DNA). Consequently, the wondrous re-shuffling **are** creation!

Another remarkable phenomenon in natural history, which strongly supports the thesis of "oriented evolution" is '*convergence*'. "Convergence is found at all leve1s" (Simpson 1953).

'Convergent evolution', and the related phenomenon of 'parallel evolution' [9], amply documented in biology (as said), consist in the appearance of a very similar (sometimes identical) physiological or morphological trait in two geographically separated species; a trait that, often, was not possessed by their nearest common ancestor (traced back along the fossil record). These occurrences are extremely difficult to explain by a stochastic, chance-based model of evolution. For certain genes (those coding for ribosomal RNA), "it is beyond belief" that their convergent evolution could possibly have been brought about by natural selection operating on independently occurring mutations (Ridley 1996, p.262).

In the case of a more conspicuous example (common features in today's mammals, all over the world), Grassé wonders: "How could natural selection, in the midst of such diversity [of forms of life], manage to favor the same forms of mammals **everywhere**, without being inconsistent with the neo-Darwinian principle**, ...**" (p. 57; my emphasis).

In summary: Grassé is convinced that "evolution is directed". It proceeds according to a "structural plan, the origin of which is totally unknown." (p.103, footnote). "Totally unknown": in a strictly scientific sense, of course. The words with which Grassé concludes his book: "The rest is metaphysics", encompassing all that is not scientifically sound.

So far Grassé; so far our assent with his assertions. We definitely disagree, however, in an essential starting point. In the sequel we shall severely challenge his declaration: "Let us not invoke G-d in realities in which He no longer has to intervene." (l.c., p. 166). These words are like saying: 'The Engineer has finished constructing that machine; now the machine runs by itself'. Our radically differing standpoint will come to its clear expression in chapter VII, (right at the start). The intervening chapters will prepare the terrain.

Gillespie, (whom we encountered before), presents a “remarkable example of parallel evolution” in two species of geese. One species, the bar-headed goose, lives in eastern Asia; the other one, the Andean goose, at great geographical distance, in the Andes of South-America. The geese of both species fly at high altitudes; they need, therefore, a means enabling increased oxygen intake. Both species achieved this by an amino-acid substitution performed at exactly the same site in their genomes. A similar case of adaptation to high-altitude flight is that of the high-flying vulture ‘Rueppel’s griffon’ (see [8]; here, in the case of the geese, we find, in addition, the remarkable phenomenon of parallel evolution!).

Earlier (p.13), we mentioned the case of the almost identical eye-muscle attachment in shark and man; this is another remarkable case of parallel or convergent, evolution. (For deciding which, we should know whether their latest common ancestor had this particular feature, or not).

As “the most striking case of convergent evolution at the molecular level”, he became aware of, Gillespie considers five particular amino-acid substitutions (out of ten that factually occurred in the genome of the langur, a leaf-eating pre-monkey). These five substitutions achieved the conversion of the amino acids previously found in the genome of the langur’s line of descent, to those amino-acids that exist, “in the **comparable positions**, in the cow lysozyme” (GiIlespie 1991, p.32; my emphasis). The lysozyme provides an innate immune response against bacteria. Such bacteria are swallowed in mass with the raw vegetable diet of these animals. The acquisition, by the langur, of the very same lysozyme as that of the cow, is a significant increase in its fitness. Remarkably, this evolutionary step was achieved at accelerated pace. The baboon, an omnivorous monkey, underwent only four substitutions during the same period of time, in place of the ten of the langur. This confirms the speeded-up evolution for realizing a specific adaptation.

As we shall learn in more detail later on, the chances for the occurrence of stochastic mutations that will cause amino acid substitutions (of any kind) at **five definite sites in a genome, are absolutely nil.** Notwithstanding, here this actually occurred. And there is much more to it! These substitutions not only took place at definite sites in the langur’s genome; they also coded for **definite amino-acids**, such as to converge to a vital particularity in the genome of quite another species (cow). Thus, we can understand Gillespie's amazement at this "most striking case of convergence". That a designer (in this case: The Designer) will use an artful device more than once, seems natural. The presumption, that it might have evolved twice by pure chance, seems rather absurd.

Up to now, we sketched the argumentations of various authors against chance-based evolution; these relied to a great part on general arguments and personal convictions. What concerns the "modern synthesis"; (i.e., neo-Darwinism), Gould had already spoken in 1985 of its breakdown (Gould 1985).

Let us now consider a recent, rigorous disproof of neo-Darwinism (it might well be the ultimate deadly blow), given by the molecular biologist Lee M. Spetner, in his book: "Not by chance; the fall of Neo-Darwinian theory" (Spetner 1996).

Spetner presents clear, calculation-based arguments unveiling the fallacies of the neo-Darwinian theory (NDT) also called 'the synthetic theory' having assimilated the laws of heredity (discovered much earlier by the monk Gregor Mendel, then forgotten). The importance of his book lies in that its strongest arguments are based on recent discoveries in the (relatively) novel field of research, called 'molecular biology'. This young branch in biological research has developed rapidly, and has already yielded very important insights into biological processes. In consequence, those arguments could not possibly have been brought forth by the earlier opponents to Darwinism. Being derived from results of strictly scientific research, they are heavy-weight. Their aim is to bring the proof that neo-Darwinism is to be rejected. It cannot be an explanation for the coming into being of the living world, the 'biosphere' in its stupendous wealth of distinct species, as we experience it at present and, no less, as it discloses itself in the fossil record.

Spetner shows that the most important source of genetic change, which could be apt to bring about such major phenotypic modifications as to account for macroevolution, are the 'point mutations' (nucleotide substitutions; see [6]. He then examines the conditions that have to be fulfilled, in order that the neo-Darwinian theory might 'work'; and he confronts these conditions with the hard facts supplied by the modern experimental research. From what has been said so far, it will be clear that in order that the NDT may 'work', the following two conditions (as formulated by Spetner) are required to hold:

"To be part of a typical [evolutionary] step, a mutation must:

1. have a positive 'selective value' [it must convey to its bearer some increase in fitness];

2. add a little information to the genome."

The first condition is self-evident. It is at the base of the Darwinian idea of 'survival of the fittest'. Admittedly, most of the mutations occurring at random are deleterious; but, NDT contends, there were enough random mutations of positive selective value for evolution to proceed up to the present state.

As to the second condition, the meaning of 'information' in living things, and its importance, has already been emphasized (more of it in later chapters). Roughly speaking, the information is contained in the genetic material (the 'genome'); mainly in the nucleus of the 'eukaryotic' cell. (The cells of higher organisms are eukaryotic, i.e., containing a nucleus).

Thus, for example in sexual reproduction, the zygote (the fertilized egg-cell in the womb) must in some way "know" how proceed in its chemico-physiologicaI activity in order to form and to grow up the embryo. (It is worth noting, that the fertilized egg already "is a storehouse of developmental information" (de Pomerai 1989, p.41). The embryo, in turn, must "know" its specific ontogeny, i.e., how to develop into the mature creature. This 'know how' is the information contained the set of paternal and maternal chromosomes, united in the zygote. (Of course, even the tiniest, asexual creature involves a huge amount of information in its ontogeny).

Clearly, if evolution is to be depicted as the growth of a 'phylo-genetic tree' (or 'bush') that, from a modest start of one (or a few) primordial living ce11(s), has developed into its present state of an exuberantly rich biosphere, comprising "at least ten million species, and some scientists think there are a great deal more" (Eldredge 1998, p. vii), genetic information, too, had to grow steadily (on the average). This implies that a mutation must, on the average, contribute a small increase in information, in order to take part in the evolutionary progress. That is the second condition.

Here, Spetner points to a remarkable fact: "Not even one mutation has been observed that adds a little information". True, there are mutations that, apparently, add information; but trouble is: they add too much at a time. These mutations are not 'point mutations'; they are physical rearrangements of the **already existing** genetic material, a kind of mutation that cannot account for a genuine increase in genetic information (see [6]) As to the point mutations, the surprising result is: "All point-mutations that have been studied on the molecular level turn out to reduce the genetic information and not to increase it" (p. 138).

This holds true even for mutations of positive selective value. A mutation causing loss of information **can** have a positive selective value; but it "cannot be typical of mutations that are supposed to help form small steps that make up evolution. Those steps must, on the average, add information"!

A good and well-known example of a mutation that increases fitness while decreasing information, is the acquisition of resistance against DDT, by insects, and against antibiotics, by infectious bacteria. The resistance is not gained by developing the respective antibodies (as we know our immune system works); rather the resistance is conveyed by a mutation, one that produces some kind of deterioration of a specific 'binding site' for a molecule of DDT, and respectively, of the antibiotic. Such specific binding sites exist on the surface of certain organelles ('ribosomes') of the insects and the bacteria. Deterioration of the *specificity* of a binding site represents a loss of information; yet it decreases enormously the vulnerability of the insect, respectively, the bacterium, to the dangerous agents. These mutations, then, had a high selective value, yet they decreased the information content of the organism.

Spetner proceeds by showing that the chances of getting a new species through cumulative evolutionary steps of this kind are exceedingly low. This would be so, even if one would, generously, admit that the two above-mentioned conditions were fulfilled by all mutations that happened to appear in one (or a few) organism(s) within a population, and that were, moreover, lucky enough to spread, up to the point of "taking over the population". More specifically: a calculation, based on data and estimates accepted by leading scientists (for the number of births required for producing one single evolutionary step, and the number of such steps required to change one species into another one), leads to the result that "only if there are at least a million potential adaptive mutations [in the genome] will there be a chance of at least one millionth that a new species will evolve" (p.104).

Speciation, then, appears to be an almost impossible event (as long as it is supposed to be brought forth by random mutations). Now, we have to bear in mind, that such almost impossible event occurred not once, but many millions of times (taking both extinct and presently living species). This should be sufficient to convince us of Spetner's claim, that NDT is a theory that has become untenable and we have to reject it. As Spetner pungently remarks: "In the 1940's, when we knew almost nothing of molecular biology, evolutionists were satisfied that the NDT could explain evolution. In the 1990's we know too much of molecular biology to be satisfied. And: "If a theory predicts events to be nearly impossible, then one cannot justifiably say that it explains those events."

Spetner therefore comes to the logical conclusion that NDT has to be replaced by a theory of non-random evolution. He advances, speculatively, a Non-Random Evolutionary Hypothesis (NREH). 'Non-random' means, here, that there exists a cause which "triggers" the formation of a mutation; and that one of the right kind to respond to said cause. NREH sees the main cause triggering evolutionary changes in changes having occurred in the environmental conditions. It is an empirical fact (we have spoken of at the beginning) that living beings possess, in all generality, adaptations to their respective environments. A changing environment most often requires a change in (or a readjustment of) adaptation. Now, NREH postulates the pre-existence, in the genomes, of a sufficiently large number of so-called 'cryptic genes' (genes that are dormant, or "switched-off"). These cryptic genes can be called into action ("switched-on"), as soon as they are useful in the process of re-adaptation. How could this be done? Well, let us consider two known facts. The first, still unexplained, is that the total number of nucleotides contained in the chromosomes frequently exceeds by far the number of them contained in the operative genes. Thus, only about 5% of the three to four billion nucleotides composing the human genome are encoded in the genes. The excess could then contain those cryptic genes. The second fact is that certain genes, known as 'regulatory genes', produce proteins which regulate the activity of other genes. Thus, "the right mutation in a regulatory gene could "switch-on" a whole array of latent [cryptic] genes" (p.72). So, we have only to assume that an 'environmental' cue triggers that 'right mutation' in the regulatory gene, with the result of producing a large evolutionary change, directed to adapt to the environmental change. Spetner buttresses this assumption by presenting some recently discovered cases of a surprising, adaptive faculty of microorganisms, enabling them to survive in a changed environment by undergoing two mutations. Their ability to produce both of these mutations within about one day, while the statistical probability for this to happen is one in about 100,000 years, is "almost unbelievable". Yet, as a matter of fact, it happens, triggered by shortage of digestible, and abundance of (previously) un-digestible food. This leads to the conclusion, that "Bacteria apparently have an extensive armory of such cryptic genes", some of which are "switched-on" by the combined mutations, thereby adapting the metabolism to the new food. (p.189; the citations here are Spetner's quotings from Cairns et.al., 1988].

Finally, Spetner draws the attention to the many known cases of phenotypic adaptation, triggered by environmental cues, without involving a genetic change at all "According to NREH, adaptive modifications in organisms occur when the environment induces a change in either the phenotype or the genotype" (p.206).

Thus :NREH leaves open two questions:

1. By what mechanism does the environmental 'cue' trigger the 'correct' mutation?

2. How did the 'cryptic' genes get into the genome in the first place?

These questions remain un-answered. "The NREH ... does not contribute to a natural explanation of the origin of life" (p.208). "The NREH is agnostic" (p.210) [as long, of course, as we choose to stay on strictly scientific grounds]. The merit of Spetner's work is to have provided us with a rigorous refutation of the neo-Darwinian theory, one that too many people deemed irrefutable.

Should we still believe, then, that chanceful stochastic mutations ("Lady Luck") brought forth humans, starting from a 'last unknown common ancestor' ('LUCA'), shared with bacteria and archaea?

A main characteristic of neo-Darwinism, just as of Darwin's original theory, is its thesis of 'gradualism'; i.e.: evolution proceeded in minor, almost imperceptible steps throughout its history. Gradualism was cherished by scientists to the point that competing theories encountered unveiled skepticism. Concerning Gould and Eldredge's theory of 'punctuated equilibrium', i.e. evolution proceeding in alternating phases of stasis and saltations; (see p.11), the attempt was made to maintain that gradualism could well accommodate even these. However, Gould and Eldredge's thesis has recently gained more and more ground, notwithstanding the fact that the saltations, typically, prove to have been rather abrupt changes.

There can hardly be a more convincing confirmation of the factually ascertained (and variously acknowledged) abruptness, than the following. authoritative statement: "…the Cambrian explosion, the remarkable episode that lasted only 10 million years (...) and featured the first appearance in the fossil record of **effectively all modern animal phyla**, ..." (Gould 1995, p.681). These "modern animal phyla" range from the important phylum of the annelid worms to the overwhelmingly important phylum of the chordata, the precursors of the vertebrates (to which we belong).

Let us appreciate the significance of this state of affairs. Ten million years (on the geologist's timescale) represent a trifling fraction (about 0.3 percent) of the span ascribed by paleontologists to the evolutionary process, from its beginnings up to modern times. During this relatively very short period (Gould: "a geological moment"!), the main divisions, the phyla, of practically all multi-cellular animals (Gould knows of only one single exception!) came into being. Obviously, this is not a gradual evolution; it is (as the name of this short geological period says), an explosion! Such explosion of richly diversified life can impossibly be the outcome of chanceful stochastic events. As we shall show later, basing ourselves on numerical data, graduality would have required an immensely longer stretch of time to achieve that (in fact, longer than the age of the whole universe). **It is a Creation**! Of course, not an instantaneous one, as was that incomparably enormous explosion, the 'Big Bang'. It was a creation in the sense, that without intelligent guidance it could not have come into being. (In chapter IV we shall see exactly, why not).

Let us close our short (and very partial) survey with demonstrating how far from well-founded the theory of evolution still was at least until 1988, (and I venture to say: still is today):

D.J. Depew and B.H. Weber published in 1988 a programmatic article, intended to pave new ways in evolutionary theory. After a critical scrutiny of no less than seven classes of "**anomalies**" (i.e. facts that do not fit well into existing theory), which arose "in the course of the last two decades", including "certain conceptual difficulties that have continued to plague Darwinism", and after having reviewed various recent attempts to amend prior concepts, they declare: "Successful new evolutionary work must better bridge the gap between nature and the human culture than the Darwinian tradition has been able to manage. This is a field where the Darwinian tradition **has failed deeply**, allowing gaps to be filled with ideological nonsense." (Depew-Weber 1988, p.347; my emphasis). So admitted by authors who 'warn', on the other side, that "**the risk of slipping** into an [in their opinion] illegitimate teleology [see next chapter] is very high" (p.346; my emphasis).

These and other declarations show how desperately those scientists have to struggle in order to keep up with a materialistic worldview based solely on physical principles. The above laconic excerpts, even though taken out of their immediate context, unmistakably betray a clear admission that the existing theory (or rather: theories) is (are) unable to explain all the facts of life. No wonder, therefore, that Niles Eldredge's recent book bears the self-explanatory title: "Reinventing Darwin" (Eldredge 1995) [17].

We are reduced by Depew & Weber to a hope: the hope, that all of evolution will one day be understood as directed by general, still unknown constraints (with, possibly, some support afforded by natural selection). Such constraints would represent a partial (but possibly dominant) canalization of the evolutionary process. Partial because, for Depew and Weber, natural selection is still "inextricably tied together" with the constraints (although acting "primarily as a negative and "pruning factor"). In this respect, it differs from Lima-de-Faria's thesis of complete canalization, from the beginning on and up to now, "banishing" natural selection altogether from evolution theory.

Be natural selection 'banished' altogether, or be it a "negative or pruning factor", Darwinian theory is in big trouble. What, after all, can explain the existence of all the adaptations, so prominently embodied in living beings? "Natural selection is the only known explanation for adaptation" (Ridley 1996, p.338). And: ..., we have no theory other than natural selection to explain adaptation; without it, we **have only miracles to fall back on**." (Ridley 1993, p.536; my emphasis, repeated almost verbatim in the 1996 edition, p.586).

Noticeably, both Brooks (Brooks et.at 1986) and Wiley (1986), whose approaches are generally positively appreciated by Depew & Weber (1988), "embrace the view that there are levels of biological organization and biological phenomena that cannot be fully explained by the lower levels of biological (much less physical) organization" (l.c. p.341). This is, no less than Grassés position, a clear departure from '*reductionism*' (the widespread approach that tries to explain all biological processes by 'reducing' them to physico-chemical ones). The basic idea behind reductionism is the assumption (or belief), that understanding life involves no more than the knowledge of the natural laws governing the behavior of inanimate matter. We shall return to this in the sequel; in chapter IX, it will moreover be shown that reductionism is of no help to materialists, either.

Depew & Weber's own program for remedying of those deficiencies of existing theory is beyond the present scope. Its essence lies, no doubt, in their quest for a (as yet unknown) set of principles derived from "tacit commitments to highly generalized pictures" and, more specifically, from "background assumptions drawn from non-equilibrium thermodynamics" (p.343). Depew & Weber's "own hypothesis" is, that such a "highly relevant set of such principles and constraints can be found ..." (p.328).

Premises of such speculative nature are believed by these authors necessary in order to "**alleviate explanatory burdens** carried not only by neo-Darwinism, but even by the "*expanded synthesis*", a theory devised to remedy the weaknesses of neo-Darwinism (the 'new synthesis'), but ending in "**failure to meet its own criterion of success**".[!] (l.c.; my emphasis). On those "highly general grounds" (of the requested "set of principles and constraints"), the doctrine of an "expanded synthesis" would (in the authors' opinion) find substantial backing (p.328). Clearly, without such yet unknown "highly general grounds" the theory is in trouble.

These deliberations harmonize very well with the opinion expressed by the authoritative expert S.J.Gould in the likewise authoritative Journal *Paleobiology*. Gould declares as "**our greatest dilemma**", the failure to find an explanation ("a clear vector") for the "**fitfully** accumulating progress", as occurred during the "first tier" of the evolutionary history (Gould 1985, p.4; my emphasis).

The true origin of the totality of species, this ultimate product of diversification of the phyla, is still a veiled secret. Yet, we feel, it must be a beautiful secret. So, let us epitomize this speculative topic with a quotation of Darwin's. His famous book "On the Origin of Species" (1859) concludes with the words: "There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms, or in one". We agree with 'grandeur'; not exactly with 'this view' of Darwin.

Let's summarize this chapter. We have seen, that:

* the subtitle of the chapter retains its validity: the theory, put into the world by Charles Darwin in mid-nineteenth century and aimed at explaining the history of life on earth, has provoked stormy turmoil, that persists up to our days.

* The dominant role of 'natural selection', one of the two cornerstones of Darwin's theory of evolution, is put in very serious doubt, by a considerable number of scientists of the first rank.

* The arduously disputed question, whether the evolution of life from its beginnings on, with its diversification into countless and widely differing species, proceeded in a smooth, gradual way (Darwin's and neo-Darwinist's 'gradualism'), or by 'saltations and stasis' (Eldredge-Gould's 'punctuated equilibrium'), has found no answer.

* "studies of modern populations [on the one hand], and evidence from the fossil record [on the other], give the impression of very different patterns and rates of evolution" (Carroll 1989, p.2). Factually: Species,

once established, persist (as a rule) essentially unchanged for millions of years. On the other hand, genetic changes occur with surprising rapidity when required, either by unforeseeable change occurring in environmental conditions, or by the endeavor of a species to adapt to life in regions with different conditions.

The forces of evolution that bring this about. are "unknown" (Gillespie).

* Paleontologists (studying the fossil record) and geneticists (deducing the course of evolution from unraveled genetic stuff) adopt "starkly different approaches to evolution" (Eldredge 1995, p.4).

* Cases of attempts to 'join ends', by filling existing gaps in understanding with "ideological nonsense" have been denounced (Depew-Weber).

* The existence, in the living world, of spirituality and active intelligence, and the possible influence of these on the course of life's evolution, is simply and completely ignored in practically all treatises on Evolution.

Having sketched a few characteristic traits of some of the more recent, diverging approaches to the theory of evolution of living beings, we turn to what is probably the most salient trait of life as such, viz: the ***purposefulness*** inherent in all its domains, - physiological, morphological, and behavioral. The study of this topic is called ***teleology*.**

Notes to Chapter I

Note 1. This is still true up to the present.

K.D. Bennett, paleoecologist, presents a “Postmodern synthesis of evolution and ecology” (Bennett 1997).

An even more comprehensive synthesis (than Bennett’s), comprising the branches biology, evolution, ecology, and others, is proposed by Allmon et.al., in their paper: “An Intermediate Disturbance Hypothesis of Maximal Speciation.” (Allmon 1998).

Recently, Princeton University Press issued “The Unified Neutral Theory of Biodiversity (etc.)”, from the pen of S.P. Hubbell, who stresses that such a new theory is “urgently needed” (Hubbell 2001).

To all appearances, the difficulties encountered in evolutionary theories so far have engendered an urge to enlarge the scope of research in the field. Without such synthesizing, the authors believe, “we will continue to see speciation [i.e., so to speak: the whole of evolutionary theory] as a **fuzzy and unknowable** collection of unrelated processes” (Allmon et.al., p.376, my emphasis).

Whether this new discipline of “Biodiversity Dynamics” will lead to a better understanding of the history of our biosphere, (better than the Darwinian theories, which failed), only time will tell.

Note 2. The most basic adaptation of all of them, is ‘adaptability’ itself (although the latter is not an adaptation in the usual sense of this term. It would sound odd to say: “Species are adapted to adapt themselves”.) But it is a property of the utmost importance to the ‘longevity’ of a species. In the course of time, the environmental conditions in which a species lives undergo changes. In order to avoid extinction, the species must adapt itself to the new conditions. **Not all species** possess the faculty to adapt themselves! We find, in fact, that species lacking the faculty of adaptability do not persist for (evolutionarily) long periods. Those living today, were usually ‘born’ not a long time ago. (‘born’, here, means their first appearance in the fossil record). No species, lacking this capacity of adaptability and being both ‘old’ and still extant, are found. This shows clearly, that adaptability is a prerequisite for a species' longevity. The question is: what is at the root of this amazing property of adaptability, so important for preventing a species' extinction?

As it appears, the answer will come with the elucidation of one of the most enigmatic and vividly discussed problems in the theory of evolution. This problem arises in the wake of the question: why sex?

The point is, there exist quite a number of species that reproduce either asexually (e.g. by spores, in plants) or by parthenogenesis ('virgin birth'; entering the biological classification as "uniparental sexual reproduction"). Since reproduction **can** be in one of the latter forms, it is not at all clear from a Darwinian point of view, why natural selection should have favored so much biparental (i.e. normal) sexual reproduction. From an evolutionary standpoint, the latter is more 'costly'; it needs two partners for fertilization. Proliferation would proceed much more rapidly with asexual or parthogenetic reproduction (as a simple calculation shows). In other words: "Greater genetic fitness would seem to come from producing parthogenetic offspring." According to Darwinism, the uniparental species should 'outcompete' the biparental ones in the 'struggle of life'.

Reality contradicts this prognostication.

The issue will be further discussed in chapter VI. Here, we solely point out the empirical fact, that only the normal sexual process ensures efficiently this crucial capacity of adaptability. Sexuality, then, is a kind of '*internal adaptation*', directed, no doubt, to produce substantial genetic variation. By contrast, parthogenesis (and kinds of asexual reproduction, in general) result in (almost) identical copies, in clones.

It is a plausible proposition, that genetic variation from generation to generation will, in the long run, produce adaptability. But for Darwinists this poses a problem: a variation does not, normally, lend an immediate selective advantage to its bearer. Rather, it is of nature "to preserve the future interests of the species" (Darlington 1978, p.449). 'Preserving future interests' (i.e., preventing extinction) is a concept that does not at all espouse the line of thought of Darwinism. That a 'disadvantageous' variation (in this case: the transition of (at most) a few members of an asexual species to sexual reproduction, with its 50% cost), initiated by an incipient process of genetic variation, should persist and spread only "for the good of future generations is most remarkable; and it is conflicting with Darwin's conception of evolution". Darlington has pointed out that "this problem of internal adaptation, ... , **baffled Darwin and was avoided by the Darwinians**" (l.c.; my emphasis).

Not only species; higher taxa profited, in the past, to an even higher degree than species, from this internal adaptation to future interests. "Sex, then, is of greatest value to clades [higher taxa], rather than to species, populations or individuals" (Stanley 1979, p.213).

Indeed, a hard nut to crack, for the adepts of 'short-sighted' neo-Darwinism. "Today, the question of why sex exists remains an outstanding puzzle" (Ridley 1996, p.296).

The weighing of the pros and cons of the respective modes of reproduction goes on. Yet, for a man of faith believing in directed evolution, the question does not arise. In fact, what would have been a human community composed of cloned individuals?

Our sages have highlighted this fundamental aspect anchored in dual-sex reproduction. Taking up the biblical story of creation of the first human couple, they say:

להגיד גדולתו של מלך מלכי המלכים הקדוש ברוך הוא, שאדם טובע כמה מטבעות בחותם אחד וכולן דומים זה לזה אבל הקדוש ברוך הוא טובע כל אדם בחותמו של אדם הראשון ואין אחד מהם דומה לחברו (סנהדרין ל"ז, לח.)

(to tell the Greatness of the Holy, blessed be He: man coins with a single mold many coins, and all of them are similar. Yet, the Holy, blessed be He, 'coins' every human being by the mold of Adam, and no one of them is similar to his fellowman.) (Tract. Sanhedrin, 37/1 & 38/1).

Should evolution have 'worked' as Darwin thought, it would have been, not only a "blind watchmaker" (to which the zoologist-evolutionist Richard Dawkins has likened it), but also the biggest 'mint' on earth.

Note 3. The renowned philosopher of science Karl R. Popper stated that a necessary requisite for a theory to be scientifically acceptable is; that it be (in principle at least) amenable to tests apt to yield either its corroboration or its "falsification". The latter would entail refutation of the theory. Corroboration, however, **never can lead to a proof** of its correctness.

As Popper rightly remarks (on the basis of strict logic), the number of potentially possible theories, for any topic in natural science, is infinite; no finite number of supporting facts for a particular one of them can outbeat an infinity of them. Corroboration at best enhances the **satisfactoriness** of a theory.

"One can sum up .. , by saying that the criterion for the scientific status of a theory is its *falsifiability*, or *refutability*, or *testability*." (Popper 1972a; p.37). And: "The criterion of satisfactoriness [of a theory] is thus testability." (l.c., p. 219). In case empirical facts apt to test the theory are lacking, "severe crucial experiments" have to be (and have often been) devised to that end. These may appear to constitute convincing evidence for the correctness of the theory that engendered them; but they **do not prove** its truth.

The history of science presents many examples that confirmed the truth of the last sentence by counterexamples.

Note 4. It may be noted that our sages the traditional Talmud commentators, too, adhered to this ancient, erroneous belief in spontaneous generation. On these grounds, they exempted from penalty the killing, on Shabbat, of certain parasitic insects, believed to arise from mold, rotten fruit, etc. In the *Talmud* (Tract-Sanhedrin. 91a), Rabbi Ami refers to a mammal (a field mouse or a squirrel) in a state of being 'half formed, half still earth'. The 'case' of said mammal is discussed from some aspects of the 'Halakhah' (talmudic law) at another place (Tract. Khulin 126b), where the traditional commentators explain it as formed from earth alone. Scientists steadily improve and correct their opinions; religious thinkers (like myself), too, have to do so.

Note 5. The most basic step in self-organization, following the initial appearance of single-celled organisms, had to be the association of the latter organisms into multi-cellular ones. Yet, a multi-cellular living being made of identical cells will not, of course, make much sense. Only the lowest life forms, as algae and bacteria, exist as associations of identical cells. Here we discover the mysterious and amazing faculty of cells, to 'differentiate'. Starting from a primitive state, cells 'know' to transform themselves, enabling them to perform a **specific** function in the multi-cellular body (e.g. a liver cell has to perform another function than a nerve cell or an intestinal cell).

Many evolutionists believe that 'symbiosis' between organisms of very different kind also had a large share in self-organization (e.g.: the role of intestinal bacteria in digestion is well-known. The mitochondria, now important organelles in our cells, also should once have been unicellulars).

Note 6. A genetic mutation (in the wide sense of the term) is any change in the genome. The change may express itself in the morphology, or the physiology, of its bearer; resp. of the offspring to which the mutation has been inherited. In this general sense, the various rearrangements of chromosomal material occurring during the different phases of cell life (e.g. during meiosis) are mutations. In a more specific sense, a mutation is a local change, occurring at a specific site on a chromosome (as provoked, e.g., by irradiation or by a 'printing error' in transcription). These are called '*point mutations*'.

Briefly: A chromosome is a double chain, coiled into a multifold helix. The chain's 'beads' are certain chemical compounds, four in number. The four initials of their names are: {A, C, G, T (or U)}.

The genetic code is expressible by these four signs; they are 'the alphabet of the genetic code'. Most remarkably, (with the exception of some variations in the DNA of certain microscopic organelles, the mitochondria), it is a fixed ***universal 'master code'***, used by all living beings. It testifies to its early origin in the evolutionary history, and to its extreme stability. "The fact that all living beings use the same four-letter alphabet for their genetic information, the same twenty-letter alphabet for their proteins, and the same code to translate ... , speaks so eloquently for the unity of life and the early origin of its master code" (Loewenstein 2000, p.189).

The human genome contains 6.6 billion letters (Ridley 2001, p.vii). Three consecutive 'letters' constitute a 'codon'. A codon determines (codes for) one of the twenty-some amino-acids used by nature to synthesize the, about, hundred thousand different proteins that build a human body. A protein is, in essence, a long sequence of amino-acids aligned, chainlike, in a well-determined order.

The processes by which a cell, starting from the about 100 to about 1000 codons contained in a gene, performs the synthesis of protein molecules, as well as the folding of these into precisely defined shapes, the timing of their production, etc., are stunningly ingenious (like, in truth, almost all life processes!); the interested reader may consult the 'Further readings' list, below. (Chapter VII. brings some more details.)

A point mutation, normally, will substitute one codon-letter for another. This may result in changing one 'letter' into another one, altering the 'meaning' of the codon such that a different amino-acid is coded for. If, by 'luck', the gene mutated thereby will produce a 'better' protein, a small evolutionary step is taken.

Note 7. Notwithstanding this expression of astonishment about the surprisingly fast appearance of favorable mutations, Kimura sees himself as forced (by emphasizing the importance of "Neutral Evolution"), to renounce (to a substantial part, at least) Darwin's argument of natural selection.

Conform to his thesis that evolution proceeded, to a major part, by way of neutral mutations offering no selective advantage (hence the denotation: "neutral"), Kimura replaces Darwin's principle of "survival of the fittest" by "***survival of the luckiest***" (Kimura 1992; p.230). The alternative he proposed emphasizes the importance of 'good fortune' for success in evolution" (l.c.). Good fortune, rather than natural selection, should have driven molecular evolution, "by mutation and random [genetic] drift" (Crow 1992, p.136).

Note 8. Out of Gillespie's many examples, let us quote the following interesting one: Vultures occasionally ascend to exceptionally high altitudes, of 36,000 feet and more. (A specifically known specimen is 'Rueppel's griffon'). This ability to fly at such elevations required a substantial improvement in the oxygen-binding capacity of the bird's blood, as compared to that of other high-flying birds. The agent responsible for oxygen association is the well-known protein hemoglobin, which lends the red color to the erythrocytes (red blood cells). It has been found, that certain mutations (actually, well-defined amino-acid substitutions) at specific sites within the so-called 'respiratory box' of the vulture's genome, enabled the increase of oxygen intake.

The urge of a bird to ascend to higher and higher altitudes can hardly be termed 'meeting a drastic environmental change'. Yet, the adaptive mutations occurred within a (evolutionarily) short time; that is what Gillespie wants to show.

"Why a vulture should want to fly at 36,000 feet remains a mystery". (Gillespie 1991, p.23).

Note 9. When two species, or any two higher taxa, share a specific feature, identical, or very similar, that was not yet possessed by their nearest common ancestor, one speaks of 'convergent evolution'. The point is, that despite these two species (or other taxa) evolving by (in general) very different evolutionary pathways, they finally arrive at possessing the very same distinctive feature.

If the nearest common ancestor already possessed that distinctive feature, one speaks of 'parallel evolution'; signifying that the feature was preserved, despite the different pathways in the evolution of the two species.

The similarity can be expressed at any level, morphological, physiological, or molecular.

Note 10. Jacques Monod received the Nobel price for his pioneering work in molecular biology. On the other hand, he was the (perhaps) most prominent proponent of the thesis that evolution was driven solely by chanceful random events. In the wake of his much-read book "Chance and Necessity" (Monod 1972), he writes, years later: "Pure chance, absolutely free but blind, at the very root of the stupendous edifice of evolution: this central concept of modern biology is no longer one among other possible or even conceivable hypotheses. It is **today the sole conceivable**, ... , and nothing warrants the supposition - or the hope - that on this score our position is likely ever to be revised" (Monod 1994, p.186; my emphasis). **How sure of himself**! Monod, a scientist of format, hardly leaves any escape-hatch open. We show in the text (see also Note 12, below), that his concept has been largely superseded, favoring instead the existence of a large range of constraints, of various kinds. These were the main factors determining the course of evolution, leaving only minor space for natural selection (which, for Monod, is the sole confining factor).

Surely, the writings of Monod in the field of his specialty could hardly have met such harsh critique as that of Küppers (cited in the text).

I could have closed this note herewith, were it not for the imperative to denounce the (in my humble opinion) serious, almost logical, errors of Monod, when he argues against the incredulity his thesis met at its first publication.

Riposting to his critics, Monod consents with Francois Mauriac's exclamation: "What this professor says is far more incredible than what we poor Christians believe". Yet, he defends his 'incredible' thesis by pointing to the fact that such difficulties, microscopic and cosmic, have also appeared in physics. He explains that, notwithstanding, "such difficulties can not be taken as arguments against a theory that is vouched for by experiment and logic" (Monod 1972; p.138).

The fallacy inherent to Monod's argument is that he ignores the glaring difference between the two cases. He argues that the difficulties in physics arise, like those in evolution, on account of "the scale of the envisaged phenomena that transcends the categories of our immediate experience" (l.c.). This is incorrect. As will be shown in more detail in Ch. IX, the physical phenomena arousing "such difficulties" are real facts, not theories. They do not "transcend the categories of our immediate experience"; they are indubitably registrable with the help of modern experimental techniques. For example, take the familiar natural phenomenon of light. Our immediate experience, a rainbow or a beam of sunlight passing through a glass prism, shows us, that sunlight is composed of many colors (a continuum of colors, to be exact). The minutest amount of light of a 'pure' color is called a 'photon'. Early research performed on light (e.g., Young's famous, classical 'double-slit' experiment, showing a beam of light to split into alternate bright and dark 'fringes'), disclosed unmistakably the wave character of light. On the other hand, Einstein's investigation of the photoelectric effect (the work that earned him his first Nobel prize) leaves no doubt that light is composed of discrete 'particles' possessing, each, a definite amount of energy. And most remarkable: It has been demonstrated, that even when such photons pass through a double-slit singly, one after one, their points of impact on a screen accumulate to an 'interference pattern' identical to that of a wave-beam.

Inevitably, then, these particles, the 'photons', possess both wavelike and particle-like attributes. A photon is neither a particle (in the classical sense) nor a wave. It is some kind of entity, we could only call a 'particle-wave'; (it has been dubbed a 'wavicle'). Yet, **we have no simple way of visualizing such an entity**. In Ch. IX., we shall see that **all kinds** of particles must **necessarily** be understood as wavicles!

Contemporary experiments proving the "irrational" nature of quantum phenomena are legion. We may wonder, how can a theory manage to describe these phenomena and even to make **correct predictions** for the outcome of new experiments! Though it fails to "achieve a satisfactory mental image" thereof (as Monod would have liked). We cannot circumvent the outcomes of crucial experiments like those of Young and Einstein; yet, these are not phenomena whose scale transcends our experience! They are hard facts, despite their causing us these difficulties in our understanding.

The same applies to the theory of relativity: Vexing **experimental facts, within the realm of our direct experience**, have endangered this theory, together with the mental difficulties it presents. By contrast, the facts of biology, miraculous as they must appear in our eyes, are perfectly accessible to a mental image**. It is Monod's hypothesis of "pure chance" which is incredible!** For example, a hypothesis based on constraints or, perhaps better, on canalization (see sequel), is more credible, and (as outlined in the text ahead) more accepted by the contemporary scientific community. Let alone the fact that the belief in a supernatural, super-intelligent Designer has earned the credence of innumerable educated people, since forever and up to the present.

Note 11. Kauffman does not enter the subjects of intelligence and consciousness. He admits that his hypothesis on life "derives from a mathematical theory which is silent on the deepest issues", such as: what it is, "to know"? And he confesses: "The disturbing answer is that such knowledge is not naturally represented in the [mathematical] models" (p.286). Contrasting with this 'putting aside', by Kauffman, of intelligence, consciousness, and the faculty "to know", these will be the cornerstones of our approach to the problem of life.

Note 12. As noted by Carroll, Gould & Eldredge claim that "natural selection is not a significant force in controlling the pattern or rate of evolution at the level of species" (Carroll 1997, p.33). Likewise, Gillespie expresses his "lingering uneasiness" from "a large scientific enterprise that has, in the main, failed to uncover direct evidence for selection" (Gillespie 1991, p.292).

Note 13. The leading paleontologist-evolutionist of the last mid-century, George G. Simpson, acknowledged the fact that the fossil record suffers from "systematic deficiencies". (A theory is more seriously challenged when the deficiencies appear in a systematic way.) He tried to explain these deficiencies using the hypothesis of *'tachytely'* (i.e. abnormally fast evolution), anticipating (perhaps even in a more drastic sense) S.J. Gould's 'saltations' (see p.29, above). His attempt to reach an explanation for macro evolution, was, however, considered a failure by the same S.J. Gould. (Carroll 1997, p.391).

Gould himself frankly acknowledges "the fossil record's notorious imperfection" (Gould 1985, p.6); a serious impediment in the attempt of reconstructing life's history. Years later, still, he deplores "the **cardinal problem** of our woefully imperfect fossil record" (GouId 1993, p.289; my emphasis).

A more recent complaint: " ... , in particular no satisfactory models can be given yet for the mechanisms leading to the origin of real novelties, . .. the great jumps in evolution." (Schuster et.at 1997, p.303).

Similarly, Kerr (2001) states: "The main problem remains; vast as they are, fossil collections are not truly representative of life in the past."

It seems clear enough that the scaffold of present theory, the fossil record, rests on rachitic feet!

Note 14. N. Eldredge confirms this in his 1995 book: “Species remain imperturbably, implacably resistant to change as a matter of course -- for millions of years” ... “an evolutionary phenomenon crying out for explanation” (p.3).

The time span mentioned by Eldredge - millions of years, is no doubt a cautiously chosen limit for multi-cellular organisms. For the unicellular organisms, this limit lies rather in the billions. In fact, microfossils (in particular those of the type designed as ’bona fide’ micro fossils) have been found in rocks and sediments dated from one to three-and-a-half billion years BP (before present), the geological time scale! The microorganisms in question, called **‘archaea**’ (formerly: archaeo-bacteria), exist today, in a variety of species. Remarkably enough, most of them live under extremely adverse environmental conditions, being called, therefore, extremophils’. Thus, e.g., the thermophiles, and hyperthermophiles, thrive in hot waters, near, resp. above, 100ºC.

Note 15. “ .. , the first unequivocal microfossils were reported from the about 2100 Myrs-old chert of the Gunflint formation” (Blum 2001, p. 9). This first finding no doubt boosted the search for microfossils in strata of even earlier periods.

As a matter of fact, Gould dated certain fossil procaryotae back to 3.4 Byrs BP. (Gould 1980; p.217; Byrs=billion years). More recently, the prominent archeobiologist J.W. William Schopf comes to this conclusion: “... it is evident that as early as ~3500 Ma [=Myrs] ago, microbial communities were extant” (Schopf 1992, p.39). Furthermore: “Cyanobacteria [once called ‘blue-green algae’] have remained..., with **identical external morphology**, for 3.5 billion years.” (Schopf 1995; cited by Carroll 1997, p103; my emphasis).

Truly amazing, (and what enables us to know all this): “... microbial cells can be preserved intact for billions of years” (Cady 2001; p.32).

Note 16: Archaean microfossils both filamentous and colonial [living in colonies] are notably similar in morphological detail to extant [presently living] prokaryotes, “a similarity evidently extending even to the mechanisms of cell division" (Schopf 1992, p.39).

We see the concordance with Grassé's statement regarding the bacteria: The archaea, too, did not change over the eons (despite all the mutations they presumably underwent). They exhibit "exceptionally slow rates of morphological evolutionary change" (l.c.).

Note 17. Near the end of his 1995 book (p.221), Eldredge frankly admits: "Even if some issues are resolved to some degree of general satisfaction, there is no guarantee that they [the problems] won't arise, phoenix-like, a generation or two down the line."

Generally, Eldredge's book advocates, like "all paleontologists", for a 'naturalistic' conception of evolution, rejecting ultra-Darwinism with its thesis of 'gradualism' and, quite generally, its "inherent myopia" (p. XI). Ultra-Darwinism, intended to supplant both Darwinism and neo-Darwinism, **suffers from myopia** just as its predecessors!

Further readings

.Margulis, Linn & **Schwartz**, K V.: **Five Kingdoms**, An Illustrated Guide to the Phyla of Life on Earth. W.H. Freeman & Co. New York; c1998 3rd edition 2000

Hunter, Graeme H.: **Vital forces,** Academic Press c2000 (the workings of the living cell exposed in detail; the book's last words are: "... ; we may understand life, but we cannot explain it.")

Rose, George D. : "**No assembly required**". The Sciences 36(1), 26, 1996. (about proteins; in particular: their neat foldings. The last sentence: "Ultimately, the divine fire that illuminates our lives is mediated by the chemistry of our proteins", is in the spirit of the present essay.)

Gayon, J.: **Darwinism's struggle for survival** Cambridge University Press 1998 (translated from French: Darwin et l'Après Darwin. **Kime**, Paris 1992)

Eldredge, Niles & Stanley, Steven M.: **Living fossils** Springer 1984 (a science book on animals both fossilized and still extant)

Béhé , Michael J.: **Darwin's Black Box** The Free Press N.Y. c1996 (recent insights into the biochemistry, esp. of the proteins (Ch.3), challenge Darwinian evolution).

Chapter II. Teleology

A major problem with which the scientific approach to life had to deal, is the teleological trend (i.e. the purposefulness, goal-directness (telos = goal), called also "finality"), which so conspicuously discloses itself in living creatures. Just as a man-made machine is adapted to perform its task, having been designed for that task, so does the relation between structure and function of the living organism suggests its having been designed. Teleology, therefore, has always been one of the cornerstones of the religious belief in a supernatural omniscient Creator. We can understand in this sense the words of David:

כִּי-אַתָּה, קָנִיתָ כִלְיֹתָי; תְּסֻכֵּנִי, בְּבֶטֶן אִמִּי.
יד אוֹדְךָ-- עַל כִּי נוֹרָאוֹת, נִפְלֵיתִי:
נִפְלָאִים מַעֲשֶׂיךָ; וְנַפְשִׁי, יֹדַעַת מְאֹד.

("For Thou hast made my kidneys; Thou hast protected me in my mother's womb. I will give thanks unto Thee, for I am fearfully and wonderfully made; Wonderful are Thy works; that, my soul knoweth right well" (Ps. 139, 13-14)).

Teleology expresses itself in the manner every limb and every organ is adapted to its function, the functions themselves being adapted to the conditions of life of the particular creature possessing those organs. Adaptations (we spoke of them in chapter I.) are featured by, and peculiar to, every single species. They make the living body adapted to its style of life, and to the environmental conditions it has to cope with. Darwinists hold that the immense wealth of all these adaptations has been brought into existence by the ever-ongoing process of variation and natural selection. In order to bring the existence of this impressive phenomenon of adaptation into accordance with their concept, teleology has been degraded to a mere so-called "teleonomy". This is to say: living things are organized and behave, **as if** they were devised towards a given goal. But in truth, it is claimed, adaptations are the outcome of "blind" physico-chemical processes, of synthesis of new products and elimination of the "unsuccessful" ones. Teleology is, they contend, only a human way of grasping things in concepts customary to the human mind. [1]

The following chapters should lend support to Grassé's affirmation: "To eradicate finality from biology is a vain attempt" (Grassé 1977, p.129).

The controversy between teleology and teleonomy is not yet settled.[2] The scientists who still stick to the Darwinian "dogma" that chanceful variations, supplemented by natural selection (i.e., survival of the fittest), were the only driving force in the drama of evolution, are legion. Some of these, serious and eminent scientists as may be, take a dreadful burden upon their conscience, by professing their convictions as unshakable truths. They should well know that the controversy is not yet settled, and that they do **not** have the last word in this matter. Dreadful, because such "truths" shatter the inner feeling of moral responsibility of many a youth; and because thereby, they contribute significantly to the growing danger of moral decline of humanity.

Facing humanity that shows clear signs of such decline, abstention from proclaiming such "unshakable truths" should be at least a practical consideration. However, for reasons of intellectual honesty, scientists should go farther and acknowledge the possibility that a theistic world conception could lastly turn out to be the correct one. Some eminent scientists, some among whom are cited above, in fact do so. Deplorably, they are rather the exception. Most defenders of evolutionary theory, apparently, feel no need to express the slightest reserve about their convictions. Yet, they cannot know for sure! The subject is of incredible depth, and our knowledge of it, however extended, is still very rudimentary. For example, concerning assignment of ancestral stock to the phyla [the broadest taxonomic divisions of living things], Grassé says: "Biologists grope in darkness". "Our ignorance is so great ..." (Grassé 1977, p.317). The influential evolutionist Futuyma chimes in: "And permeating evolutionary biology is the recognition of our continuing ignorance (**although we too seldom dare admit it**) of the mechanism of development, ..." (Futuyma 1988). A more recent statement is: "We know very little about the phylogenetic relationships of living things. ...In the present state of our ignorance ..." (Ridley 1993, p.370; 1996, p.386).

At stake here is, of course, the age-long dispute about the 'intelligent design' of the world. The most illustrious defender of the 'design thesis' was, no doubt, the 18th century clergyman-theologian William Paley. Paley's teachings have been harshly attacked by some, (notably by the famous philosopher of his time, David Hume, as well as by modern scholars such as Richard Dawkins and Daniel C. Dennett); yet they have been supported by others. A remarkable modern defender of the thesis of intelligent design of life is the biochemist Michael J. Béhé. In his book "Darwin's black box" (Béhé 1996), he argues convincingly that the knowledge gained lately in the domain of his profession invalidates the arguments brought against Paley by his antagonists, both ancient and contemporaneous. There can no more be any doubt, he states, that intelligent design was at work, even if knowledge of who was the designer is lacking. "The conclusion of 'intelligent design' flows naturally from the data...". It "can be made quite independently of knowledge about the designer." (pp. 193, 197).

At hand of **several examples** presented by Béhé in some detail, he shows that what is **already** known of the biochemical workings within a living cell constitutes sufficient proof that intelligent design **must** have been at work. And, he adds, there can be no doubt that future research will only augment the weight of his argument. [3]

In my judgment, the scope for amplifying and extending Béhé's proof is already practically limitless. Examples from cell biology that corroborate the 'design thesis' can be multiplied at will (almost 'ad infinitum'). "The powers of invention in the living world are immense" (Grassé). These inventions, we see now, are designed. They clearly point to the Intelligent Designer.

Of course, the adepts of the teleonomic concept will after all maintain that this "enormous amount of intelligence" (Grassé), embodied in living matter, is nothing else but an illusion of the human mind, produced by the combined effect of the slow and gradual accumulation of random mutations in the genetic material, and of natural selection leading to the "survival of the fittest"; or even (according to the "neutralist's" view; see note [7] of chapter I), to the "survival of the luckiest".

Take your pick as to whom to believe. The most scientists can say (considering para-psychological research as unscientific) is, that science has no means to prove whether extra-physical phenomena exist, or not.

Therefore it has to restrict itself to the endeavor of trying to explain everything physically. Yet, we remind ourselves of Elliott Sober's words about evolutionary theory: "It is a sound working hypothesis (which may just possibly turn out to be mistaken)".

Notes to Chapter II

Note 1. A counter-argument often uttered against “divine design” is the apparent imperfection of many adaptations. Even if this would be the case, we cannot know for sure the reasons of it. It may well be that the reason why it appears to us as an imperfection is our lack of a deeper understanding. A classic example for this is the well-known judgment of Hermann von Helmholtz. This genial scientist and philosopher of the nineteenth century praised “nature” for the design of the human ear, but severely criticized the design of the eye. Only later it became apparent that the alleged imperfection of the eye’s optic is in fact a selective advantage; being a trade-off between picture quality and field of view; the widened angle of vision allows the detection of potential danger in a field approaching a hemisphere. Still other reasons are thinkable.

Grassé, (referring to a book of Ivanoff 1953, which treats of the subject in detail), says that, quite generally, “subtleties” in organisms are “sometimes mistaken for imperfections.” (Grassé 1977, p.105).

Note 2. The attempt has been made to do away even with teleonomy (seen by the proponents as goal-orientedness, yet without the goal being the cause of the evolutionary course taken), “in the same sense as automata are goal-oriented but without the goal being the cause of the machine’s operation” (Loewenstein 2000, p. 327-8). Let’s leave aside whether this comparison makes sense; (the automatic machine has not evolved by chanceful stochastic events. It has been designed to operate towards reaching the goal!).

In place of teleology and teleonomy, Werner Loewenstein suggests that a simple physical law, like the law known to describe the timely evolution of the motion of mechanical systems, should describe the course taken in biological evolution. In physics, the law states that the evolution in time of mechanical processes is such, that a certain mathematical quantity (a combination of the parameter-values involved in the mechanical motion) assumes a stationary value (a minimum or a maximum in most cases). Postulating an analogous law for the evolutionary process means pushing reductionism (see chapter I.) to its extreme. Yet this is what the eminent cell-biologist Loewenstein (encountered already in chapter I.) tries to do in his recent book "The Touchstone of Life" (l.c.). No doubt a valuable book, written by a world expert in the branch of cell communication (transfer of physiological information between, and within, the cells of a living organism). We shall return to it in chapter VIII, because the author advances an avant-garde thesis regarding consciousness. Here we want to repost to the attack Loewenstein leads against teleology towards the end of his book.

The alerted teleologist who has assumed the fighting posture will soon return his sabre to its scabbard, and smile: It was a false alarm. It is all-too evident (all-along the book), that the author's argument originates in wishful thinking. One can almost feel his exaltation, when he writes: "One now also may bid farewell to teleology - its last afterglow" (p.326). This sounds fairly self-assured. But it is only a hope, as he says later-on: "But now, at last, we may **hope** that that lady [teleology] will relax her hold ..." (p.328). Words of a man who languishes, waiting to be delivered from the yoke!

Hope is also the escape from the stifling enigmas of biological sophistication. Loewenstein acknowledges that to the question how "these optimized and stringent codes of biological communication" originated, "**we have no answers yet,** to be sure". "Our best **hopes for an answer**…" "even a glimmer of a wink is welcome". These hopes focus on some long-sought "physical constraints" that would have determined the "course Evolution **may** have pursued". (pp. 188-193; the emphases are mine).

What are these hopes based on?

Loewenstein swings the banner of "thermodynamics and information theory". We shall speak of these items in chapter IV; but let us anticipate the main point. Loewenstein contends that "Information and entropy do not balance" [in the teleologist's view], (p.327). In chapter I. we quoted extensively from Grassé's important book. On its first page Grassé points out: "Life constantly defies the law of entropy **without violating it**". This implies that the balance is maintained with precision.

No serious defender of the teleological standpoint will ever contend that life is not subjected to the law of entropy (for that matter: to any of nature's laws!). The peculiarity of life lies in its **defying** this law, not in violating it. This will be explained in chapter IV, where we shall discuss Loewenstein's arguments in more detail.

Could the hoped-for physical constraints and, more generally, Loewenstein's "reductionist efforts", possibly come up to the authors longings? Since it is only about hopes, we can take our time. In chapter IX, we shall give a clear answer; it will be in the negative. This said, it should be acknowledged that the author is laudable for presenting his suggestions with some (moderate) reserve.

Note 3. The Darwinian-minded Michael Ruse admits (to his dismay, I suppose) that thanks to his being a practicing research scientist, Béhé's argument has received "much attention". From reading Ruse's reposte, it becomes obvious that he tries to dwarf the weight of Béhé's argument. He mentions only a single one of Béhé's cases in favor of design (the mechanism of blood clotting), but passes silently over several others, no less convincing. Ruse reposts with the meaningless statement: "Let me say simply that this claim seems not to be well taken." His counter-argument "simply" is: "There **simply is no evidence** that organic characters are so complex that they could not have been produced by an evolutionary process" (Ruse 2000, p. 11; my emphasis). But this is precisely what Béhé has shown. He has furnished **evidence** that physiological mechanisms, at the level of biochemistry, "could not have been produced" other than by intelligent design. Therefore, Ruse's above-cited argument means a plain, unsubstantiated rejection of the evidences presented by Béhé. For such rejection to be valid it does not suffice to say: "there is no evidence". The purported evidence must be invalidated (should it in fact be erroneous) by a convincing proof of its fallacy. Preconceived Darwinian tenets are, of course, no proof in of themselves. Knowing this, Ruse 'urges' Béhé.' "to understand" that evolution did **not** necessarily proceed in a straightforward way. Instead, [so Ruse], "**it may well have been** that in the past certain elements **were there**, bridging the gaps". However, these gaps are a central point of Béhé's argument. In order to undo them, Ruse tries to assure us, that somehow "in the past certain elements were there", kinds of 'spare-parts', just good enough to be fitted temporarily into the gaps, until evolution had managed to produce those highly sophisticated parts that we find today. When ready, these “parts” were substituted for the temporary ones. The latter, having become obsolete, “are now missing” (l.c.).

This ad-hoc “may-well-have-been” proposal, far from being “simple”, is a fuzzy complication of a process that was intended by the founders of the theory to be smooth and straightforward. Is the exchange of “parts”, suggested by an avowed Darwinist, not a departure from gradualism, inconsistent, therefore, with existing theory? (It can hardly be accommodated by Eldredge Gould’s ‘punctuated equilibrium’, either!)

If this is meant to be a new (or a modified) theory, it can be refuted even more easily than ‘classical’ Darwinism. As long as it is in this fuzzy form, let us only ask a few questions:

“Elements were there”: where did they come from? If they evolved at the place where they were needed, we have only lengthened and complicated the path of evolution; and if they were suited to “bridge the gaps”, by what were they more explainable without appeal to design than those of today?

If they did not evolve ‘in situ’ (i.e. at the same place), what is their origin? Were they ‘transplanted’ from other, perhaps more primitive organisms? And is evolution to be thought of as workman, skilled in the exchange of parts?

The weakness of Ruse’s argumentation against Béhé’s “claim”, four years after its publication, can rather serve as a vindication of the latter. In any case, Ruse finds himself forced to admit: “As things stand today, one has to admit that there is a gap in our understanding of the natural emergence of life from nonlife” (Ruse 2000, pp.11-12).

Chapter III. Knowledge and Belief

Ernst Häckel, probably the most fervent adopter of early Darwinism ("more Darwinist than Darwin"), belonged to an epoch that still believed that, in principle, man can know, rationally, ultimate truths. And so, he could utter the bold, self-confident phrase: "Wer die Wahrheit kennt und sagt sie nicht, der ist fuerwahr ein erbaermlicher Wicht". (He, who knows the truth and does not proclaim it, is truly a pitiable guy). (Häckel 1878, p.7).

This has changed since; we "know that we do not know", in what concerns ultimate questions about nature, not to mention spiritual matters (both treated in later chapters) There remain only beliefs; prominently so also in theoretical physics (where this is openly declared). One of the leading atomic physicists of our days, Frank Wilczek (discoverer of the law of "asymptotic freedom" intervening in nuclear forces), declares (1987): "Let us recognize that there is a hierarchy of belief among scientific theories. At the top of this hierarchy are theories like QED and QCD, which are fundamentally simple and very definite and which explain a wealth of data in quantitative detail". QED (Quantum electrodynamics) and QCD (Quantum Chromo Dynamics) are today almost universally accepted theories. If such experimentally corroborated theories are founded on belief, the theory of evolution, in whatever version, can certainly not claim more than that. As already noted, expressions such as "it is believed", "might be", "could be", "perhaps", "presumably" and the like, pervade the relevant literature. Depew & Weber speak of "the entire fabric or web of our beliefs" (Weber-Depew 1988, p.345).

Even the toughest teleonomist cannot deny that the disclosure (as seen from a human vantage point) of overwhelming wealth of ingenious design at every level of life, from sub-cellular physiology to the subtlest workings of the human brain, testifies to what we humans can only characterize as sublime wisdom.

Could it possibly be (חכמה לאחר מעשה wisdom ex post factum), as contended by teleonomists? Is it not, rather, סוף מעשה במחשבה תחילה (action induced by prior thought)? We may well ask those biologists referred to at the beginning who stand for the first alternative, what is their belief founded on? (and there cannot be any question that theirs is only a belief!). Diving into contemplation of the marvelous processes of life we have come to know, one must come to the conclusion (often explicitly admitted in recent scientific writings; see chapter VI.), that we are facing "mystery". And the intricate mechanisms operating in these mysteries testify to what our intellect can only characterize as the outcome of most ingenious design. In Ch. I, we have dealt with the explanation-begging adaptations.

Yet, it must be stressed again here, that the manifestations of sublime finality (goal-directedness), and the manifold of refined methods that implement this finality in all the ramifications of life, are absolutely stupendous. This is true for all phases of ontogeny (the development of a mature organism, starting from a single-celled fertilized ovum in the womb). It applies, as well, to the functioning of every cell during the life cycle of the grown-up body. To try to convey within the present frame even the slightest impression of the vastness of its extent would be a hopeless enterprise; it would take much more than the space of this work to do even minimally justice to the subject.

Most teleonomists will, despite all, contend that this whole body of information (= 'intelligence') we highlighted (rather poorly) in the foregoing two chapters, came into being by pure chance combined with constraints and natural selection. If someone, after having taken the pains to get thorough insight into the incredibly vast wealth of deep wisdom implemented in the processes taking place in the living organism, outlined above, still believes that all this is brought about by purely stochastic chanceful microscopic events in the arrangement and rearrangement of the atoms composing the genomes of all the millions of species, it is perhaps not possible to prove to him the fallacy in his thinking. But: **his opinion is only a belief**; and it is one that is **really hard** to believe in. The belief of the faithful Jew appears much more logical and well-founded (besides that it relies on a firmly based religious tradition; we are not dealing with that aspect at all, here!).

A hundred years ago the scientific community, proud of an alleged "ultimate insight" into nature, an insight which solely needed (so they were convinced), further elaboration of all the details, looked pitifully back to the medieval "dark ages of ignorance". The scientists of those times had done the same versus antiquity. And so do we today in relation to the mechanistic, deterministic worldview of the end of the nineteenth century: the theories of Relativity and Quantum mechanics have shattered that simplistic picture of reality. What is our assurance, then, that a similar process will not occur again, be it in a hundred, be it in a thousand years, elicited by the advent of a new thought-revolution, resolving the perplexities plaguing the scientists of today? Can we imagine what will be the status of "creationism", then?

Trying to find remedy to the admitted weaknesses of the original Darwinian theory without the need of recourse to creation, adepts of neo-Darwinism, and of "ultra-Darwinism, so sure of itself" (Grassé), base their innovative theories (mainly) on physico-chemical explanations. As mentioned, this method is called 'reductionism' (i.e.: reducing biological phenomena to physico-chemical ones). By doing so, these evolutionists go, in fact, from bad to worse (or rather, from our standpoint, from bad to better!). As we shall see, some of the most advanced concepts in physics have led scientists to take their last refuge from most puzzling insights they lately gained about elementary physical processes, to - - - creation!

In our concluding chapter (XI.), we shall try to show that a vanguard conviction (i.e.: a belief!), expressed by one of the most prominent scientists of our days, concerning the true nature of all elementary processes, is almost congruent with Jewish-Cabalistic faith professed by authoritative representatives of Judaism.

Before this, however, we should consider that extraordinary phenomenon disclosing itself so markedly in living stuff, namely: order.

Chapter IV. Order

Order is a salient characteristic of life. We have already cited Lima-de-Faria: “Order prevails at every level”. Not at all levels is this order manifest; at the level of the biosphere it is! Every cell of a multicellular living being has to be in its right place; and, likely, every structural molecule of the cell has to be in its right place with respect to all the others taking part in the cell’s structure. So it has to be with each part of the body, with respect to all its other parts.

Order is measurable. Instead of using a ‘yardstick’ for measuring (manifest) order, physicists prefer to use the concept of *entropy*, which is a measure for the degree of disorder. (The famous physicist Erwin Schrödinger has in fact proposed the term “negentropy”, as a more direct measure of order. However, the traditional terminology has prevailed). One of the fundamental laws of nature is the so-called “second law of thermodynamics”. It states, that in a self-contained (‘closed and isolated’) system the entropy cannot get smaller (meaning that the degree of order cannot increase). Whatever processes go on in such a system, the total entropy of the system will either stay at its value (which is the case only, when the processes going on are reversible), or it will increase, (as is the case in all factual situations) [1].

Although the second law applies strictly only to closed and isolated systems (which is an idealization), its use in actual systems is a very good approximation to the real situation. That is: an increase in entropy is the result in the overwhelming majority of all natural processes (an example demonstrating this will follow in a moment). This means, that there is no spontaneous (overall and manifest) ordering (since this world represent a decrease in entropy). Rather, in most situations, there is a spontaneous disordering. (An important exception is crystallization).

One of the great riddles in cosmology today is the following: Since the total entropy of the universe (a self-contained system, as far as we can know) is steadily growing, the entropy immediately after the instant of the (presumed) “Big Bang” must have been extremely low. The eminent mathematician Roger Penrose (prominent contributor to modern cosmology, co-winner, with famous Stephen Hawking, of the Israeli Wolf prize) has calculated an estimate of that lowness in the nascent universe (Penrose 1989, chapter 7). Assuming the universal validity of the second law (in accord with the accepted opinion of the scientific community), he found that the chances, for a universe as ours, to come into being, spontaneously, with such low entropy is -- not one in a million nor one in a billion-- but --- one in N. What is this N? N is such a huge number, that it cannot even be written out in the usual notation of 10^n (the exponent, 'n', giving the number of zeroes after the 1), since this 'n' itself would have to be a very large number. In Penrose's own words: "This now tells us how precise the Creator's aim must have been: namely to an accuracy of one part in N" [with N as just explained] (Penrose 1989, p.445). The number N is immensely greater than the total number of elementary particles contained in the whole known universe.

This low entropy is one of the mysterious facts about the "birth" of our world. What is however more directly relevant to our present subject matter is, that **life is unique**, in that it strives to go back to low entropy, while all other "normal" natural phenomena proceed along a path of increasing overall entropy.

To give an example: Heating up a body increases its entropy, by increasing the disordered internal motion of its constituent molecules.

The second law teaches that when, for instance, one part of a system cools down another, hotter, part of it (e.g. a cube of ice, cooling a drink), thereby lowering the entropy of the latter part (the drink), the entropy increase of the colder part (the ice cube) outweighs its decrease in the hotter part (the drink). The total entropy of the system has therefore increased. While this applies rigorously to a closed and isolated system only, it is normally the case also in ordinary systems where the restrictions of closure and isolation are not fulfilled. Entropy is increasing, "except under very special circumstances". This means that order in general (and in the measure it exists) is spontaneously, gradually deteriorating. The towering exception to this rule is --- life! The building-up of living matter out of its non-living constituents represents an increase in atomic and molecular order, i.e. a decrease in entropy. "We ourselves are configurations of ridiculously tiny entropy" (l.c., p. 410).

Here, in the case of a living thing, no direct external entropy-lowering influence, (such as cooling, i.e. heat extraction) is required. On the contrary, in general, warmth promotes and accelerates the unfolding of life. The opposite happens in the natural processes occurring in dead matter (decay, erosion, etc.): Generally, when a given chunk of dead matter possessing some structure is left to its fate for some time, these processes (exclusive of the action of bacteria, which are living things) will have increased the entropy.

Ilya Prigogine, Nobel prize winner for his groundbreaking work on non-equilibrium thermodynamics, has tried to lay the theoretical foundations for an explanation of the phenomenon of "Order out of Chaos" (this is the title of his 1984 book). In his investigations into non-equilibrium states he found that, under certain special conditions, far-from-equilibrium states of open chemical systems will "shift" from one stationary state, having a given value of the. system's entropy, to another state with lower entropy. He believes that in the early stages of biogenesis such far-from-equilibrium states did in fact prevail. "It seems reasonable to assume that some of the first stages moving toward life were associated with the formation of mechanisms capable of absorbing and transforming chemical energy, so as to push the system into 'far-from-equilibrium' conditions."

This "reasonable assumption" is to be joined to many, many others, in the hypothetical history of life according to Darwinism. Moreover, the continuous process of evolution, with entropy-lowering all the way through, is not explained thereby, unless it be assumed that the biosphere was in a 'far-from-equilibrium' state throughout its history. Even then, one would have to postulate that those special conditions required for entropy-lowering shifts to occur, persisted continuously (or, at least, occurred repeatedly).

All this becomes much more acceptable, intellectually, when we recognize a goal-directed driving force, immanent in all these physico-chemical processes. Without admitting such a teleological driving force, we remain with the fact that "the problem of biological order [which] involves the transition from the molecular activity to the supra-molecular order of the [living] cell ... is far from being solved" (Prigogine 1984).

This entropy-lowering principle of life applies not only to a whole organism, not only to an individual living cell, but also to every one of its constituent parts; in particular, to parts carrying genetic information. As mentioned in chapter 1, information existing at a given moment suffers degradation (i.e.: loss of useful informational value) concomitantly with the elapsing of time. In information theory, this degradation is expressed in terms analogous to those expressing the increase of entropy with time. Precisely the inverse process is observed in life. The orderly arrangement of atoms, as we find in all living things, is an expression of information. The primary source of the latter is, of course, embodied in the genome of the organism. Ontogeny (the development of the body, parting from the fertilized ovum) brings the atoms of the nutrients into the required orderly constitution of the body; that is: the entropy of the atoms is lowered. (This is obvious, at least, for the plants; they draw their nutrients from inorganic matter.)

More globally: the complex of atoms forming the genes of a new species contains new genetic information, including rearrangements of prior genes inherited from the predecessor of which the new species 'branched off' (as believed to have happened in evolution). The appearance of this new information is equivalent to a lowering of entropy by the increase of informational order.

Now, it has been pointed out by Nobel-laureate Christian de Duve, that unless evolution had proceeded sufficiently fast, the genetic information newly gained (through favorable mutations) would have been lost before a new species could have had time to establish itself in the web of life. We see there-from, that very general principles of physics and information theory must be "defied" by life, in the process of evolution. A favorable mutation, just "born", has to "fight for its survival" against the destructive forces of entropy increase and information loss.

A mathematical investigation of the problem of information loss by Nobel-laureate Manfred Eigen yielded a relationship between error rate in the genome copying process and the maximal amount of information that can be reliably transmitted. For higher organisms, sophisticated "proof-reading" mechanisms are required for faithful reproduction of all the information contained in the genome, if an "error catastrophe" is to be avoided. Of course, 'almighty evolution' has provided such mechanisms to all the higher organisms! But apparently the problem is more stringent for the pre-biotic era; de Duve has brought it up again, in this connection, at the Dublin (Ireland) meeting on "What is Life?" (September 1993). It is in fact not obvious how the mechanisms safeguarding the stability of genetic information in the biotic era, postulated by Eigen, could possibly have been operating in the pre-biotic era, when the normally required enzymes were still non-existent. Then, when the 'naked replicators' (replicating molecules unassisted by enzymes) needed a selection mechanism (see Küppers, above), those mechanisms could not possibly operate. Attempts to overcome the problem have been made, by postulating various sophisticated molecular mechanisms, "but none with sufficient persuasiveness" (Depew & Weber 1988, p.320).

That the information was not lost, must therefore be seen as an expression of the fact that the entropy of genetically important molecules did not increase, even in the pre-biotic phase. "Life defies constantly the law of entropy (without violating it)" (Grassé 1977, p.l).

We have cited this statement· already in Note 2 of the second chapter, where we began countering Loewenstein's anti-teleological argument. We are now in a position to conclude the rebuttal of that argument.

As said, Loewenstein is an avowed reductionist. Should reading the book's main text not make this sufficiently obvious, it is clearly expressed in its last chapter. Referring there to the "unassailable logic of such abstractions" as successfully made in mathematical physics, he states: "And there are no reasons to expect any inherent limitations of the application of this process to biology" (p.330). Such unlimited application is precisely the searched-for aim of the adepts of reductionism.

We could therefore toss his case into the same bag with those of all the other reductionists. However, his argument is worthy of special reference, for two reasons: Firstly, Loewenstein advances a definite model for the reduction of biological phenomena to uniquely physico-chemical ones. Secondly, he turns the tables, attempting to use his model (a hypothesis, in fact!) as an Occam's (Ockham's) razor for defeating the teleological argument, treated in chapter II. The two headlines on one and the same page (p. 326) spell it out. It will be remembered that, from the start (see Preface and its note), we brought this ‘razor’ to bear against materialistic Darwinism. So, Loewenstein’s attack calls for a reply.

First, anyone who wants to use this ‘razor’ should be careful not to cut into his own flesh.

In chapters 7 through 10 of his book, Loewenstein describes the information flow, within and between cells of a multicellular organism. This he does (if I may venture to make a judgment) with superb eloquence and clarity. Yet, he uses in these descriptions, at several occasions, terms (like “may well”, “must have been”, “would”, “if”), that express the hypothetical nature of the statements involved. The author apologizes for it (p.210). This is only fair. But, at the same time, he makes the attempt to ‘cut away’ a rival thesis with help of arguments using these terms. A doubtful enterprise! Even more doubtful is Loewenstein’s effort (in chapter 13 of his book) to launch a novel, starkly hypothetical (up to the limit of a “Panglossian view”; p.318) explanation for consciousness. Promptly after which he, in fact, unsheathes the ‘razor’. (We shall· come to it in chapter VIII; here, we denounce the principle).

Again and again, Loewenstein acknowledges the mysteries embodied in life. The “Origin of natural codes” (the genetic one, and others) is “one of the great enigmas of biology” (p.188); “the question of how the hard- and software here [in the organism’s information flow] came into being is no less a mystery than that of the genetic code”(p.189). “ .. even a small piece of a life Circus is a universe” (p .199).

With the words: “And so, mystery meets mystery”, Loewenstein closes chapter 13, ready to take the ‘razor’ in his hand. In face of this **‘mysterium tremendum’** of life, he is not deterred from using an uncorroborated thesis as an ’Ockham’s razor’ against teleology!? [2]

We anticipate here, that Loewenstein postulates a principle of “minimized information expenditure”, operative in evolution. We can easily see, that using Ockham’s razor in this context is cutting heavily into one’s own flesh. The proposed principle means, that evolution chooses a definite path in its progress: that of minimal information expenditure. In all the millions of cases when evolution ‘produced’ a new taxon, be it at the top of the hierarchy (a kingdom), or at the bottom (a species), or anywhere between, where this way of 'minimum expenditure of information' was active (according to Loewenstein), it was at the same time a way of stunning, extreme sophistication, up to "the limits of what the physical laws allow" (Bialek, see below).

That such should be a consequence of pure luck, intervening in an evolutionary process subjected to (almost) total 'physical constraint' (namely: of minimal information expenditure, all along evolutionary history), appears absolutely unbelievable. [3]

Leaving the unbelievable in the hands of Ockham, the conclusion should emerge, that teleology could be the only logical way of understanding evolution as governed by the rule of minimal information expenditure.

It can be said quite generally, that the more deterministic, intricate, refined and sophisticated we find the workings in our world, the stronger grows the teleological argument. Loewenstein, unwillingly, sees to it!

Let us now return to the issue of conservation of genetic information: "Sufficiently fast" (of de Duve) may well be conflicting with the Darwinist's requirement of very slow gradual evolution. However, it is, in all appearance, even more conflicting with the factual rates of mutation, on which the possible rate of Darwinian evolution is dependent. Rates of mutation (rather: of permanent fixation of a mutation) have been extensively determined, and they are very low. Expressed in terms of probability, it will take one hundred million to one hundred billion years, until an amino-acid substitution at a given site within a gene (this is the kind of mutation most relevant here) can be expected to occur. This is true, not only for vital sites where, of course, only non-deleterious (and, therefore, rarely occurring) mutations can have left their imprints. Even at non-functional sites, where mutations could have proliferated without sensibly (if at all) reducing the fitness of their bearers, mutation rates are not much higher (although they definitely are higher!); and the same is true for the many 'synonymous' (i.e. information-preserving) substitutions that could possibly occur at vital sites.

It appears, then, that the conservation of acquired information in the genome of any species is another manifestation of that perplexing phenomenon, so characteristic of living things, of entropy lowering, resp. (as in the present context) of opposing its increase. Without it, the information loss, which is imperative according to Shannon's Information Theory, would have destroyed any manifestation of life soon after its emergence.

Irrespective of these concerns about information loss, the extremely low mutation rates, mentioned above, should make it most difficult to believe in an evolution based on purely stochastical grounds. It can hardly be doubted that the changes which were needed in a primitive genome in order to transform it into the genome of an intelligent being, required more than a mutation once at a definite site. This already would have required a very substantial part of the total time that was available for evolution (three to four billion years, according to current theory). But it is almost quite as certain that, more than once, two mutations at adjacent sites in a vital gene were required. The probability for this to happen, even only once during that span of time, is practically nil!

Let's take as a concrete example the normal mammalian eye: According to Darwin's theory, it has evolved through numerous very small adaptive improvements, starting from the most primitive light-sensitive organ (no more than a little heap of light-sensitive molecules) shown to have been possessed by very primitive animals in the remote past. This represents a span of about one (certainly less than two) billion years. Clearly, numberless favorable mutations in a.-a.-codons, respectively (what amounts roughly to the same) favorable new combinations of amino-acids, needed in order to produce the new proteins, as well as the genetic instructions for their organization into the sophisticated construction of that organ (the eye), were required for achievement of this ingenious innovation; and all these had to occur during said time-span. To maintain, that only two or three of these, necessarily, had to be in adjacent (or at least, well-defined respective) positions in the extremely long DNA molecule, seems absurd. So, there must have been very many small evolutionary steps on the eye's road to perfection. Recall Darwin's words: "If it could be demonstrated that any complex organ existed, which could not possibly have been formed by numerous successive slight modifications, my theory would absolutely break down", cited by Ridley, (1993, p.326), who adds: "If there are exceptions, the theory is in trouble".

There is trouble! The fact, that there was "simply not enough time" for an evolution based mainly on chance, has sometimes been overtly acknowledged by biologists. Thus, the influential geneticist D.J. Pritchard advances an "epigenetic theory of evolution" in order to cope with the "**deficiencies of current evolutionary theories**", the lack of sufficient time being one of them (Pritchard 1986, p.305; my emphasis).

The late Sir Fred Hoyle, illustrious astronomer (he was doubtlessly well-versed in astronomical numbers!), declared: " .. the information content . of the higher forms of life is represented by 10^{40000} (a one with forty thousand zeroes after it); this number representing the specificity with which some two thousand genes [a rather small genome; for comparison: man has about 30,000 genes], each of which might be chosen from 1020 nucleotide sequences of appropriate length, might be defined. **Evolutionary processes would require several Hubble-times for such a result."** (Hoyle 1981; my emphasis). (A 'Hubble-time' is the estimated total age of the Universe since the Big-bang, i.e., some fifteen billion years; this is about four times the assumed time-span during which life evolved from the earliest beginnings up to the present!). Hoyle's argument clearly leads the thesis of 'blind evolution' *ad absurdum*.

We have already spoken, in chapter I., of the abruptness with which evolutionary processes are found by paleontologists to have taken place. We stressed, how much this abruptness contradicts the Darwinian principle of gradual evolution (a principle that Darwin himself declared a 'sine qua non' condition for the validity of his theory); and how much it appears incompatible with an evolution left alone to chanceful stochastic changes. In the light of those low mutation rates, as outlined above, events such as the Cambrian explosion (see p.29) clearly eliminate any possibility of having been the outcome of Darwinian evolution.

In this respect, we can now make a special point concerning the (putative) evolutionary development of *Homo Sapiens* from the line of the great apes. According to currently accepted theory, this development started about five million years ago. In evolutionary terms, this is almost 'just yesterday'! Jacques Monod (whom we know from chapter I) acknowledged the "astonishing swiftness of this evolution, attested-to by fossil skulls" (Monod 1972, p.161). If the swiftness of the skull's evolution [i.e.: its increase in size along the evolutionary ascent from ape to modern man] is astonishing, what should be said about the brain itself? Not to stress, that the cleft between the mental capacities housed in these skulls is immensely deeper than the difference in their physical sizes, is like admiring the swift workings of the mechanical engineer who designed and produced the computer's housing, while passing under silence the stunning feat of the electronics engineer, who designed and produced the computer itself in the same time frame.

Evolutionists usually 'measure' the progress in brain evolution by the increase in brain weight. But the increase in brain weight (attested to by the sizes of fossil skulls) is not enough to explain the superior mental capacity of humans! (The elephant's brain is even bigger than man's). The extremely complex, subtle organization of the newly acquired 'gray matter' had to be encoded in the genome! How, then, was it possible (at such extremely slow pace of genomic evolution, as stated) to effect all the necessary amino-acid substitutions in those genes already possessed by our 'predecessors', in addition to the de-novo creation of all the new genes? Both of these were required for transforming an animal brain into the toweringly superior human brain, with its capacities of abstract thinking, self-consciousness, language and creative power; a brain so incomparably more intelligent than that of any other earthly creature (in particular: of any purported predecessor)!

How in the world could 'blind' evolution have managed to evolve the human brain in this evolutionarily short time-span, as stated? I, at least, can testify that I have not found as yet a single word of a serious attempt to reconcile the (in all appearance) irreconcilable discrepancy between those two contentions: The rate of establishment (fixation) of substitutions in existing genes and of formation of new genes, on the one hand, and *the purported evolutionary emergence of man* (Homo Sapiens) in said time-span (that is: since the branching-off of Homo from a line of Pithacus), on the other hand. It has been pointed out, that an explanation in terms of "some sort of 'quick and dirty' compromise" is to be rejected, because "time and again we see that the nervous system functions at the limits of what the laws of physics allow" (Bialek· 1997, p.276). This means, that the degree of sophistication in design has reached its **physically possible maximum**.

The currently accepted assumption about the descendence of man seems highly questionable. Douglas J. Futuyma states in the recent re-edition of his important book "Evolutionary Biology" (Futuyma 1998), that no fossil remains intermediate between ape and humans have been found (p.762). Futuyma leaves no doubt, that evolution of the living world has in fact taken place; yet he admits that "the entire study of evolution is in disarray" (l.c.).

And so is, in particular, the study of the origin of homo sapiens. Yet, judging from the available evidence (as outlined above), the conclusion to be reached is, that there must have been a supernatural, spiritual driving force, for evolution to have accomplished this extraordinary feat. The appearance of man on earth is truly a Creation in its own right.

Hoyle said: "would have required" so and so much time. Yes! It would have, had life's evolution proceeded in a random fashion; driven by a supernatural force, it could have, and in fact has, proceeded at a drastically higher speed.

Starting with Lima-de-Faria's concept, which grasps evolution as discernable from the very beginnings of the world and spreading treelike throughout its history, as ascending, in the realm of life, to instinctive behavior, unfolding then the faculties of intelligence up to the lofty heights of man's superbest creations of mind, -- we see the overwhelming manifestation of the One Great Spirit. We hear the קול דממה דקה (sound of a gentle stillness), once heard by the prophet Elijah, pervading all existence.

This line of thought will guide us in the sequel.

Notes to Chapter IV

Note 1. In chemistry, a number of (practically) reversible processes are known, implying that the entropy stays constant during their course. But, for reversibility to be achieved in a strict sense, the process must be carried through infinitely slowly. Evidently, this is impossible. Constant entropy, then, can be maintained only approximately.

A system is 'closed' if no exchange of matter with the outside can take place. With an 'isolated system', no exchange of energy (e.g. radiation) can take place.

Note 2. Let us lay bare Loewenstein's line of attack: The great French 18th century mathematician Joseph L. Lagrange has produced a masterpiece in mathematical physics. He has reduced (again: 'reduction' !) the laws of motion of massive bodies to one single simple rule. These laws were first formulated concisely by Isaac Newton in the form of three mathematical formulae. The rule uniting these into one single mathematical expression is called *'the principle of least action'* (more exactly: of stationary action; meaning either a minimum, a maximum, or a saddle-point, within a given range of one or more variables).

This principle stipulates that any system of massive bodies evolves in time, under the influence of any forces that may be acting on it, in such way that the 'action' of the system, between a given starting-time and a given later time of its evolution, is stationary; (in the normal case: a minimum). Under 'action' here, is understood a certain definite mathematical expression combining all the relevant parameters of the system. It is not seldom a complicated formula; but when the latter is known, and its station-point calculated, the data whose values are in general the desired goal of the computation flow from it quite easily. This technique has proved very fruitful in solving certain problems.

Here, Loewenstein comes in with postulating that a Lagrangian principle applies also (mutadis mutandis) to biological evolution. In place of 'action', put 'entropy'. Do we not know that, like 'action', entropy tends to assume a stationary value? It is a maximum in this case, but this is easily reformulated in the desired sense. As we already know, the mathematical formulation of information goes in parallel (antiparallel, in fact) with that of entropy. Information is equivalent to order; ergo, it can be conceived as 'negentropy' (i.e. negative entropy) just like order. (For the latter, this has been exposed above).

This leads Loewenstein to the thesis, that "biomolecular systems tend to minimize information expenditure" in the course of their evolution (p.91). In words paralleling the principle of 'least action' in physics, this says: biological processes proceed, during evolution, along **that** path (out of all possible paths) which is 'most information-economical' one (p.327). Basing himself on this "proposed guiding principle of biological evolution" (p.91), Loewenstein starts the second part of his 'anti-teleological' argument: "The [teleological] idea of an immanent goal, or purpose, implies that the biological system knows beforehand which among the many possible paths is the most information-economical one". And this "implies that, at each evolutionary bifurcation, the system possesses the information for the most information-economical path." (l.c.). This implied 'precognition', in Loewenstein's view, is unbelievable. Teleological arguments, therefore, have to be 'shaved away'.

Now, first of all, the argument leans on a proposal, a hypothesis in fact; - not (not yet, at least) on an established law of nature. The proof that this conjecture is correct has still to be brought. As long as this is not done, Loewenstein's proposal is no less debatable than the teleology/teleonomy controversy itself. Well, should it one day be found to hit the truth, its formulation will certainly have to be judged a brilliant achievement. For reasons quite independent of our present concern, I dare doubting that this will happen. For, let us state the proposed principle in a simplicistic way. It is, as if 'Evolution' would say to 'Entropy': "Sorry, I can't help creating some amount [a **large** amount, indeed!] of information, a thing that hampers your drive to maximize yourself. But believe me: I shall do my best, to economize information as best I can."

Is such a principle suited to bring forth such cornucopia of exuberant life, such a huge store-house of information, such "immense power of invention" as realized in our biosphere? Is it apt to produce a human brain, a thinking 'device' capable of consciousness and of superior creative power? Capable to defy (without violating it!) the universal law of gravity, which dictates that bodies on earth, including the fleeting air, are irrevocably bound to earth! (We remember man's achievement of putting his feet on another celestial body; and greater achievements will follow, no doubt!)

On top of all this, we should put our finger on Loewenstein's argument of 'precognition', just discussed. Clearly, it can be applied only to **teleonomy** (called by him teleology), not to a genuine teleology based on religious faith. To see this, imagine for a moment, that Loewenstein's hypothesis were correct. Far from challenging the creationist's position, it would enormously strengthen it. It is in line with our advocation for (partial or complete) determinism in evolution, as exposed in chapter I. (we shall return to it in chapter VII.). Of course, the precognition originates in the Designer. He determined the (putative!) rule of 'minimal information expenditure', just as He determined the rule of 'minimal action' (and for that: all laws of nature). Clearly, then, the argument of precognition is nothing else than a determinist's countering the atheistic-**teleonomistic** position. (See hereto also note 4, ahead).

Note 3. As a matter of fact, Loewenstein feels, in all appearance, the insufficiency of an unwieldy system of physical constraints for explaining evolution. This is no doubt the reason, why he makes repeatedly appeal to the "serendipity" in evolution. Yet, it is not at all easy to marry 'serendipity' with a principle of 'minimized information expenditure', in evolution. As it stands, it would mean that not only one minimum path was available, within the manifold of all the possible paths, at every evolutionary step. One would be forced to postulate, that two or more minimal paths within the manifold (almost) always existed. Otherwise, how could there have been an opportunity for serendipity to be at work, choosing (by natural selection, or by pure luck) the most 'fit' one, out of this multiplicity? A complicated assumption like this certainly cannot serve as an Ockham's razor against other tenets. Without assuming this multiplicity, we forcibly must believe in an unbelievable serendipity that made the paths of minimal information expenditure to be, at the same time, also paths of maximal sophistication; and this, all around biological evolution. Such coincidence is thinkable, only and alone, when it has been designed by a Superior Spirit.

This is not what Loewenstein intends, indeed. I presume hitting Loewenstein's intentions, with saying, that, in his opinion, evolution is a long series of fortuitous ("serendipitous") events, interconnected by paths subjected to the constraint of minimal information expenditure. But then, we have fallen back on neo-Darwinism, a theory which, in essence, preaches just this (namely: 'Lady Luck'), held in bounds by physical constraints. And neo-Darwinism has been, I think, sufficiently defeated in the present work.

Note 4. Anyway, we do not really grasp the deeper significance of Lagrange's 'action'. For the physicist, it is merely a mathematical trick for condensing Newton's intuitively well-graspable equations into one single formula, even though the object of the latter (the 'action') cannot be given an intuitive meaning. We should not doubt, however, that there is a meaning; yet it must be found in deeper layers of nature's secrets. The same would apply to a principle of 'minimal information expenditure', if true.

The Creator has been called by a great Jewish scholar of the 19th century, Rabbi Samson Raphael Hirsch, "the Greatest Master of calculation" ("der grösste Rechenmeister"); this would perfectly fit the putative facts. Who, if not He, could have been 'precognizant', that "minimal information expenditure" would lead to a biosphere brimming over with information, with intelligence? Or what else could have brought it about? Contingency? Lady Luck? Serendipity (the combination of the two former)? Who can believe that?

Chapter V. Intelligent Evolution

The term 'intelligence' has a broad meaning. It expresses itself on three levels of biological activity. The first of these (in an order dictated by the present context) is the intelligent organization of biological molecules, such as to form a living organism.

In chapter I. we have cited Grassé's words: "... any living being possesses an enormous amount of intelligence, called information today". This information, embodied in the 'intelligent' organisation of lifeless matter into a living being, is the first level.

The second level is the instinctive behavior of a living thing. We cite here a few definitions of instinct:

Instinct is "an involuntary response by an animal to an external stimulus resulting in a predictable and relatively fixed behavioral pattern." (Encyclopaedia Britannica, Micropaedia, ed. 1985).

"... an innate impulse, intuition, unconscious skill" (Concise Oxford English Dictionary, 5th ed.)

"... a natural ability or tendency to act in a certain way, ... , without having to learn or think about it" (Longman Dictionary of English Language & Culture, 1992).

Clearly, the definition of 'instinct' is not clearcut. Yet, a rather lucid picture of it obtains, nevertheless, from the merger of the above.

A strictly scientific, comprehensive definition of "intelligence", on the other hand, encounters considerable difficulties (see e.g. Encyclopaedia Britannica, entry Intelligence). Yet, it will not be far from correct to say, that intelligence characterizes itself as the faculty to learn, to evaluate information, and to put evaluated information to use in choice making, decision taking, acting, and creating. Attributes of intelligence are: sagacity, prudence, cleverness, shrewdness etc. This is the third level.

We shall inquire into the extent of these three levels and the relationships between them.

The first thing to note is, that although the first two levels are included here in the term ‘intelligence’, there is a difference in their usual meaning from that of the third. They are innate properties; we shall therefore design them as ‘innate intelligence’, in distinction from the third level, which we shall call (where necessary, for clarity) ‘free intelligence’.

Inasfar as information is equivalent to intelligence (“it is still the same thing” (Grassé)), we have to consider the coming into being of even the lowest organism, (say, for the present purpose: of Darwin’s primordial single cell), as an early embodiment of innate intelligence. This is certainly true as soon as that ‘organismic entity’ contains genetic information, i.e.: information for reproduction of any kind other than simple chemical replication; e.g. by a kind of cell division, Primarily, the genetic information resides in the genetic material, called the ***genome***. All living beings (even viruses, these creatures at the very borderline between living and dead matter) possess a genome, consisting of molecules of nuclear acids. These are of either of two kinds: DNA (deoxyribonuclear acid, which is the basic genetic material of most living species), or RNA (ribonuclear acid, in the genome of certain kinds of viruses). These molecules are the essential constituents of the chromosomes, the well-known microscopic bearers of the genes, responsible for ontogeny and inheritance.

The intelligence embodied in the genome (by way of the information stored therein) leads from the most basic levels, ontogenesis (buildup of the body) and autonomous nervous system (determining the physiological activities of respiration, metabolism etc.), to those of action, both unconscious and conscious, either intentionally or in response to the environment. Actions are commonly divided into ‘instinctive’ and ‘intelligent’ actions (deriving from the second and third levels of intelligence, respectively).

Let us elaborate somewhat on these general lines, focusing, to begin with, on the stage when a particular genome of any higher organism has just been formed within a fertilized ovum. The union of a fatherly and a motherly set of chromosomes is called a ‘*diploid*’ genome, It is the source from which all information, subsequently to be accumulated in the growing body, will build up. Every cell of the evolving organism will contain a replica of that genome, a huge repository of information that directs the various physiological activities **within** the cell. Moreover, exchange of information will also take place **between** cells.

The summit of this development in 'higher' animals and in humans is, of course, the formation of a brain and of sense organs. The buildup of these latter, like of all other parts of the nascent organism, takes place in the early embryo, following exactly the 'instructions' (i.e., the information) contained in the genome. (Other, so-called epigenetic processes, also contributing to development, are not our concern here.) The brain, endowed with multifold capacities, captures imprints from the outer world (received by the senses), and registers them in the memory, for evaluation and later use, when they will be retrieved from memory.

We come to a crucial point: Where is all this intelligence coming from?

Postponing an answer to this question for a while, let us ascertain first the extent of intelligence existing in the living world, and the influence it may have had on the course of its history (i.e., of evolution).

We saw in chapter IV, that the universe came into being, possessing an utmost low entropy. According to a universal law (the 'second law of thermodynamics'), applying to inanimate matter, entropy had to start increasing. Thus, it increased, during billions of years, until one day, in all appearance inadvertantly and surprisingly some large molecules which happened to be formed by random chemical synthesis, "decided" to defy that universal law and to organize themselves into macromolecules of sophisticated construction and unlikely low entropy. They had also the remarkable property to replicate themselves; a kind of information transmission. With this event, so we have to understand, the first seed of embodied intelligence was born. It was born with a pronounced urge to further and further organize surrounding matter (by forming new organisms), lowering its entropy. The seed grew up, proliferating both in extent and in richness of forms, creating means (sense organs, brains) for better gathering and evaluating information about the environment, for better nurture, housing, locomotion, communication, etc.; then came thinking, learning and evaluating, reading and writing, calculating, creating, assessing reality, meditating about the significance of existence, reaching other celestial bodies, (etc.).

We used the term: 'embodied intelligence'. The substrate of information (be it a biomolecule, a book:, or a magnetic tape or disc) is, by its very nature, the embodiment of some sort of intelligent stuff. Evolution, then, presents itself as the workings of certain factors (whose nature we need not specify at the present stage) that act on a primordial intelligent stuff: varying it via its embodiment, amplifying it, diversifying it, etc., etc. In short: **evolution is, in truth, an unfolding of embodied intelligence.** (Note that the term 'unfolding' applies to something that exists already in potency).

Living beings even at the (nearly) lowest levels of organic organization, perform evaluation of information and suitably corresponding action, even in unforeseen and unusual circumstances (e.g., amoebae do this; see below). Instinct, this primitive form of information-evaluation, is, common to all living creatures, including plants (some kinds of them possessing it even in highly developed form, e.g. carnivorous and heliotropic plants). Finally, huge useful information is contained in the plethora of macromolecules forming every living cell (see chapter VI.).

The uncountably varied expressions of intelligence in animals known to us (e.g. nest building and adorning (!), brooding, feeding, hunting, and millions more), are ordinarily characterized as 'instinct'; that is: as an innate capacity, transmitted by genes from parent to offspring. There is no need for the latter to learn; they get it with birth. This is in contrast to humans, whose instinct is almost nil; instead, they are endowed with a high degree of free intelligence.

This is the popular view. Yet, Grassé teaches us that there is **no distinction of principle** between intelligence and instinct. Both are intelligence in essence (as is also organic organization, although called today: 'information'). Instinct is 'innate intelligence' (to distinguish from the usually understood kind which, as said, we call here 'free intelligence').

Instinctive action is steered by genetically stored information; that is: by a kind of innate intelligence we use to call 'instinctive knowledge'. Knowledge as such has its roots in both instinct and intelligence. What is peculiar to instinctive knowledge (as distinct from knowledge gained via free intelligence) is, that it is essentially hereditary; offspring have the same instincts as their parents. Most lower animals don't have to learn from their parents anything about the satisfaction of their basic needs, and the behavior required thereto. There can be no doubt, then, that the knowledge of the required instinctive behavior is inscribed in the inherited genome. It sits there, present already in the single-celled zygote (fertilized egg), on the same footing as the information of how to build out of that zygote the complete body, with all its limbs, organs, etc. etc., fully developed. In total, indeed, a huge amount of instinctive intelligence, judging from the immense variety of instinctive behavior in the living world.

Human intelligence, as conceived by us, is a faculty of mind, of intellect, of spirit. It is a compound of experience, learning, thinking, weighing alternatives, taking decisions and, most probably, something more (this 'something more' is difficult to define; we shall have to deal with it in chapter VIII. [1]). The whole of it we call *'free intelligence'*, meaning that it is not bound to gene expression.

Yet, free intelligence is not an exclusive faculty of humans. Animals too possess it to a certain extent (as most owners of pet animals will know). We shall show this at hand of some poignant examples, and then try to present evidence that even primitive animals are, in all appearance, endowed with some rudimentary form of free intelligence. From all this we shall conclude, that the development and spreading of free intelligence, perhaps no less than that of the innate ('bound') kind (i.e., of instinct), **had a weighty influence on evolution**.

This is by no means a new idea. "The biologist who focuses on the evolution of species emphasizes the development of intelligence as a powerful tool of adaptation and survival". (Encycl. Britannica, Macropaedia, **9** (1974), p. 678 a; **21** (1985) p.710). This alone confirms, that intelligence was an important factor in evolution. Many researchers in the branch of 'Animal Behavior', (called 'ethologists', or 'behaviorists') point out, that (so-called) *'cultural transmission'* is a widespread and important feature in animal life. Such transmission is an expression of some kind of intelligence.

It will lend a selective advantage to its practisers. Selection operating on this basis might be called ‘intelligent selection’.

It is deplorable that, factually, serious treatises on evolution appear not to devote to this important aspect of evolution the weight it deserves. The reader of the relevant literature gains the impression that this insight tends to be ignored or, at least, neglected. This observation of mine is based on quite a number of treatises on evolution consulted. A good example is the comprehensive textbook, met with already in chapter I. (Ridley 1993/1996). It seems not to attribute any significant role to intelligence. The study-case of a pride of lions discussed there (p.315), clearly demonstrates this attitude:

“If the lions of one pride become more efficient at hunting, perhaps because of some new behavioral trick, natural selection will favor them. If the trick is inherited, that type of lion will increase in frequency relative to other types of lion”. Continuing (p.319): “But what happens in the phenotypic [i.e. not inheritable] case? The answer is too obvious to labor over. [sic! [2]]. The individual lion with improved hunting ability will survive and produce more offspring than an average lion; but no evolution, or natural selection in any interesting sense, will occur. The trait will not be passed to the next generation. Natural selection cannot work directly on organisms”. “Genes are crucial if natural selection is to take place”.

Quite obviously, the existence of other factors, such as ‘cultural transmission’ or ‘intelligent selection’, is ignored here. “The trait will not be passed to the next generation”, because “natural selection cannot work directly on organisms”. This implies, that learning a trait (such as a hunting trick) from parents, cannot be perpetuated over the generations unless it is anchored in the genome. This implication is contradicted by the results of observations and experiments performed with higher animals (including lions).

Most illuminating is a series of experiments performed on the Japanese macaques (snow-monkeys). I cite: “In 1953, a comprehensive research was conducted on the social behavior of the snow-monkeys living on the island Koshima in Japan. In order to encourage the monkeys to venture into the free area, sweet potatoes were dispersed on the shore. After a few weeks, the researchers were surprised seeing. a young female monkey, called Imo, rinsing the potatoes from adhering sand. No more than a few weeks elapsed until other young monkeys imitated Imo. Within ten years, the hygienic measures of Imo were adopted by all monkeys, except those twelve or more years old. Two years later, Imo presented, to the researchers' astonishment, an even more impressive idea: The researchers added to the monkeys' diet wheat grains, dispersed on the shore. The monkeys used to collect them, grain by grain, out of the sand. One day, Imo took the initiative, filled her hand sand with grains and threw the whole into the seawater. The sand sank down immediately; whereas the grains remained floating, ready to be collected. This new custom, too, spread among the monkeys and, as before, was adopted by the younger ones only". (1993 מחשבות translated from Hebrew) An early, thorough account on Imo and her 'pupils' has been given by one member of the research team (Kawai 1965).

Our lesson herefrom is:

1. Imo had the good idea (the 'trick') to make use of the difference in the buoyancy of water for seed-grains and sand. (Of course, this is not to mean, that Imo had any idea of buoyancy. Presumably, once, in a mood of anger about the tedious work of grain collecting, she had thrown a handful of sand with grains into the sea. The relevance to intelligence lies in her having observed the floating of the grains, and in realizing the inherent advantage of repeating the procedure.) –

2. Other young monkeys, not necessarily her offspring, learned from her example.

3. The improved skill of gathering food was passed to the next generation.

Clearly, no heredity factor was involved here; nor will anyone sensible advance the ridiculous proposition that all those monkeys that learned the trick had undergone that particular mutation in their genome which incorporates the idea of the trick. This group of monkeys will have a selective advantage over other groups that have not learnt Imo's trick (at least as long as their food will consist of particles lighter than water and dispersed in sand or the like).

This seems to be a convincing refutation of the thesis that "genes are crucial if natural selection is to take place". Incidently: the lioness takes her cubs with her on hunt; in all probability, the cubs learn hunting behavior from their mother. Let us note, moreover, that the very fact of having the 'good idea' of a new hunting trick will, in general, be traceable to the animal's "individual learning" (i.e.: to intelligence), rather than to "some developmental accident in the lion's nervous system", as suggested by Ridley.

Other large carnivorous mammals, e.g. wolves, also take their offspring with them on hunt; play-hunting is widespread among many species and probably trains the young in hunting. "An improved hunting procedure of a group (pride, band, etc.) is a phenotypic difference with respect to the hunting procedures of other groups of that species. If it is transmitted to later generations, the new trait represents an evolutionary step." This should be so, irrespective of whether the transmission is effected through genes or through tradition, contrary to Ridley's contention. If the trait conveys an advantage, it increases fitness, i.e., it promotes survival. And quite generally (at least for animals living in groups, especially in groups with a predominant herd-instinct), a "trick" devised by the leader that improves life conditions will grant a selective advantage over other groups; this, purely on the grounds of what we have called 'intelligent selection', without genetic improvement. The trick will become "tradition ". As Sober states it: "Learning can provide the requisite heritability just as much as genes" (Sober 1993, p.209).

It has been remarked by Gould (cited by O'Neill, 1994, p.181) that "early language would have had a selective value". This, too, implies that a totally non-heritable skill, a main tool of intelligence, is apt to promote evolution.

It is to be noted, that we spoke uniquely of social transmission, not involving any kind of genetic inheritance. It is a much debated issue, whether advantageous features of this kind could ever, in some arcane ways, get anchored in the genome.

Until recently, there was an (almost general) concensus, that Weismann's 'dogma' of the strict separation (called: the 'Weismann barrier') between the 'germline' and the 'soma' excludes any possible intrusion of acquired and somatically expressed information into a gamete (which would enable its heritability).

During the last half-decade or so, a number of works have appeared, that challenge this 'ban' on what has been called 'Lamarckian heresy', (A precursor of Darwin, J. B. De-Lamarck, had professed the 'heritability of acquired characters', implying the possibility of said intrusion). We shall return to this issue later-on. Let us point out here solely: should the conjectures (and this is all we have today) that Lamarck's ideas possess, after all, a kernel of truth, turn out to be true, this would add a glorious chapter to the 'marvels' implemented in living beings (dealt with in chapter VI.), because it would require a complicated cell mechanism aimed at boosting evolution in most sophisticated ways. (Marvels are a central theme in our essay!)

Other attributes, besides intelligence, that seem to us essential to human nature (such as emotion, compassion, affection or love, altruism, solidarity, etc.) are also found expressed, to various degrees, in animals.

Peter Kropotkin, (the famous anarchist leader who fled from Zarist Russia to the West; renowned also for his works in geography, zoology, and other areas), has provided us with an outstandingly vivid description of animal social life, emphasizing the aspects of sociability, attachment, joy of life and mutual aid (Kropotkin 1939).[3] Here are a few examples:

About "The life of the bee" (so admirably well described in Maurice Maeterlinck's well-known classic bearing this title), Kropotkin says, emphasizing their unparalleled social organization and mutual aid: "These small insects, which so easily might become the prey of so many birds, and whose honey has so many admirers in all classes of animals, from the beetle to the bear, also have none of the protective features ... , without which an isolatedly living insect hardly could escape wholesale destruction; and yet, owing to the mutual aid they practise, they obtain the wide extension [distribution over earth] which we know, (etc.) ... Thus when a new swarm of bees is going to leave the hive in search of a new abode, a number of bees will make a preliminary exploration of the neighbourhood, and if they discover a convenient dwelling-place, - ... -, they will take possession of it, clean it, and guard it, sometimes for a whole week, till the swarm comes to settle therein" (p.31-32).

Even more remarkable are the ants [4] and the termites. They are "at the very top of the whole class of insects for their intellectual capacities", which express themselves in both their social organization and other aspects of their lives.

Birds are well-known for their intelligence already from schoolbook stories. Kropotkin points out the cranes as "extremely sociable, living in most excellent relations, not only with their congeners [members of their own genus], but also with most aquatic birds." Their astonishing prudence and intelligence lets them grasp instantly a new situation, to which they react accordingly. They post sentries, to watch a feeding flock. Had they once been surprised by man, they send out several sentries in turn before frequenting that place again. Taken into captivity, the crane "sees in man, not a master, but a friend" (so testified by the famous Brehm, author of the classic "Tierleben" ("Animal Life")).

Mutual help, Kropotkin emphasizes again and again, is essential in evolution. Falcons exemplify this in a striking way. Those species of falcons that practize mutual help are thriving, while others, not practizing it, are decaying, despite their "almost ideal organization for robbery" (p.26).

"Mutual aid is met with even amidst the lowest animals" (p.27). As to affection, resp. love, parental love in animals is all too well known. But also grief over the death of a friend-animal has been observed. Certain animals (e.g. elephants and crabs) will not leave an agonizing fellow until it becomes clear that it cannot more be helped. Kropotkin reports having himself observed, one day, how a big crab (Limulus), fallen upon its back in the corner of an aquarium tank, was rescued by its 'fellows'. The task having been rendered difficult due to the presence of an iron bar, the animals labored unsuccessfully during hours. Dispairing, they mobilized two more crabs from the vicinity, to come to their aid (p.28). Humans, in the best case, would have done the same under the given circumstances.

These properties of animals, social life and mutual aid, go hand in hand with their intellectual capacities. Kropotkin emphasizes in particular the high intelligence of such 'lower' animals as ants (see [4]) and termites, bees, pelicans, cranes ("superior intelligence"), and parrots ("at the very top of the whole feathered world; the gray parrot has been referred to by the best naturalists as the 'bird-man' "!), even certain kinds of beetles. Of the 'higher' animals, Kropotkin mentions the beaver-rats ("a very high degree of intellectual development"), beavers, jackals and foxes ("extraordinary intelligence"). One should list also the bats, the dolphins and whales, and the elephants (he mentions shortly on p.55). An outstanding example of "extremely altruistic" social life of **mammals** offers the African 'naked mole rat'. Living in colonies, "they are working for the good of the colony" (Sherman 1997).

Do animals possess consciousness? Do they act consciously?

As to the higher animals, "we find far more instances of **undoubtedly conscious** mutual help ... " (Kropotkin, p.33; my emphasis). An impressive example of conscious mutual help is reported by the researcher in animal consciousness Marian Stamp Dawkins**:**

The way of life of the vampire bat entails that members of a community of these "highly social animals" remain hungry for days. Mutual help is imperative here.

Seeing a starving member of its community, a vampire bat will feed it, by regurgitating part of the reserve of blood it has sucked shortly before from its prey. However, this is not done indiscriminately. Preferentially, near relatives will be fed; then 'friends' of the past. Highest priority will enjoy a bat that has fed the present donor in the past. Dawkins remarks that "this is only an extreme case of a very widespread phenomenon among animals" (Dawkins 1993, p.57ff). Ants represent another extreme case (see note 4).

Although, then, this altruism is apparently practized on a "tit for tat" basis (i.e. the donor bat "expects" reciprocality), one should have to admit that such speculative deal-making behavior can hardly be expected from animals unable of conscious thinking. Beyond this, we shall try to show in the sequel that, basically, consciousness exists also in very primitive (compared to the bat) presently living animals. Moreover, that there is at least some indication that such was the case already in the remote past, at early stages of the appearance of those beings on earth.

In the first place, it seems obvious, that actions that are directed by 'free intelligence' cannot normally be performed in a state of unconciousness. If so, animals which can be shown to act by free intelligence do possess conciousness (although not necessarily self-conciousness [5]). The examples to follow show-up signs of (in all appearance) free intelligence in several 'lower' animals, among them two very primitive living beings:

1.) Learning, one of the main criteria for free intelligence, is by no means restricted to the "higher" animals. "The basic fact that insects are capable of learning is well documented". "Many species ... are frequently very good and fast learners" (Avital-Jablonka 2000, p.354). Equally documented is their use of 'tools'. Thus, e.g., the sand wasp uses pebbles as a "hammer" for tightening the sealing of its burrow (Denny 1980, p.236).

Serious research has been conducted on learning capability of lowest kinds of animals. Coelenterates (yellyfish, sea-anemones etc.) do change behavior as a result of previous stimulation. They are not (as formerly believed) "a delicately adjusted mechanism whose activities were made up of a combination of simple responses to immediate stimulation"; rather does the animal play an active role in interacting with its environment (Rushforth 1973, p.165). Even those most elementary, microscopic and single-celled (or, as some prefer to call them: acellular) animals, the protozoa, living in almost every small drop of pond-water, have been shown to possess learning capability. For habituation, i.e. "learning not to respond", the "evidence is compelling" (l.c., p.117); for learning by "trial and error", (e.g. to escape, by swimming, from an uncomfortable location), the evidence is almost convincing (l.c.; p.83ff).

Examples of that kind can be multiplied almost indefinitely. "Animals must learn a substantial part of their behavioral repertoire through trial and error interactions with a dynamic and uncertain environment" (Douglas 1995).

2.) Another criterion for free intelligence is risk evaluation. This comes strikingly to its expression in the so-called "fight or flight response" of many higher animals. Being an everyday experience (e.g. with cats), it has been thoroughly investigated by ethologists (animal behaviorists), also in lower animals. The response shows clearly the animal's ability to choose between these two alternatives, after weighing the relative chances, and taking a decision of action. It is characterized by a delay between the stimulus and the animal's response. The delay is utilised by the animal for weighing risk, evaluating chances and, thereupon, taking a decision. It is a special case of the topic (well-studied by ethologists) of "delayed response".

Delayed responses, too, have been observed in "lower" animals. In octopus, e.g., thorough study has revealed both learning ability and delayed response. (Octopus is that feared, eight-armed mollusk (boneless animal) living in the depths of the oceans. Its stretched-out dimensions reach up to six meters). As another example, wasps (like many insects) bring-in the daily food for their youngsters (larvae), morning-morning. The 'digger wasp' does this only after a morning-inspection of its nest, judging the amount of caterpillars required as food for that day (Rosin & Kalat; cited by Dewsbury 1978, p.358). Here, the delay in following the natural drive to feed is used for making an assessment.

This ***time-delay*** between stimulus and response is a distinctive feature of intelligence as we know it in man. It is lacking (at least almost so) in instinctive responses. A delayed response, therefore, is indicative of free intelligence.

3.) The following examples focus on various expressions of free intelligence in crabs, beetles, bacteria and amoebae (generally considered as 'lower animals', if as animals at all). All these intelligent creatures have, of course, their instincts. Yet, I believe, the examples show sufficiently that not all of their behavior can be dictated uniquely by instinct.

Thus, the behavior of the crabs in Kropotkin's narrative cannot be instinctive. The fact that they were faced with a completely unusual situation of contingency and acted accordingly (quite as humans would have acted in an analogous situation), clearly discloses free intelligence.

In a similar case, (also reported by Kropotkin, l.c., p.28), beetles of certain species realized a strived-for goal by "combining their intelligences", overcoming "the artifice of Man devised to thwart their endeavor". This, likewise, discloses genuine 'free intelligence'; the prescription of how to 'go around' the obstacle created by the human intelligence, cannot possibly exist inscribed in the beetles' genome, in order that it might be executed instinctively.

<u>Bacteria:</u> Koshland's studies on the ubiquitous bacterium E.coli (as well as on other bacteria) have yielded several interesting results (Koshland 1979). These microscopic creatures are clever swimmers. They know to follow the most favorable track, namely: in the direction of increasing food concentration (an activity called "chemotaxis"). It is equipped with a respectable number of receptors adapted . to record various external stimuli, as well as with a kind of CPU (Central Processing Unit), with a response regulator, etc. Judging from the sophisticated construction of the bacteria's organism and from the bacteria's behavioral patterns, Koshland concludes that, in a sense, these creatures possess the faculties of discrimination, choice, memory, learning, instinct, judgement and adaptation which, all of them, "we normally identify with higher neural processes" (p.1061).

Among the many other remarkable activities of bacteria, there are:

a) their cooperative behavior when under stress (e.g., they form a 'plaque' on our teeth during night, when 'food' is scarce);

b) the "adaptive mutagenesis" of the individual bacterium. In other words: the bacterium undergoes a mutation in its genome, in order to adapt itself to new environmental conditions. **How** this is achieved remains (apparently) a mystery.

c) communication between the bacteria takes place by means of exchange of genetic material.

These and various other activities are described in an article entitled: "Smart Bacterial Colonies" (Ben-Jacob 1997).

Amoebae: Grassé (1977, p.213) relates an observation made by "the eminent Swiss protistologist" C. Penard (1938) on an amoeba, (a pseudopodic, single-celled animal). A minuscule pin had pierced its body. Yet, the amoeba managed to escape, by a clever action of rescue. What the amoeba in fact did was, to split itself up from the periphery of its body onto the pin, which enabled it to escape. I ask: Is this less an act dictated by free intelligence than that of the man who cuts out, or bites off, a piece of his flesh bitten by a serpent; or that of the man who amputates with his own hands a leg trapped in a landslide? In particular, the direction of slicing of the amoeba's body (starting from the periphery), seemingly leaves no other choice than to ascribe the amoeba's action to free intelligence. [6]

Seeing such an utmost primitive animal, inadvertently exposed to an unusual situation threatening its life, finds the way to evade the dangerous situation and to preserve its life, we must admit that this creature acts intelligently in reaction to evaluated information (the threat to its life by the pin in its body). It is hardly imaginable that the instructions how to act in the case of impalement are registered in the amoeba's genome (in which case we would have to consider it as instinct), seen the contingency of such an event under natural conditions. So, we must, in all appearance, conclude that the action of salvation was performed through conscious free intelligence.

The credibility of this observation is underlined by Grassé: "It has been observed by trained naturalists who know how to remain objective while facing the strangest spectacles ... , and able to measure the complexity of structures as well as the behavior involved" (l.c., p. 214).

In the phylogenetic tree (the picture of evolution of all life forms from a common ancestry, as depicted by evolutionary theory), amoebae occupy a place already in the early stages of the emergence of life, probably not very far from that of bacteria. The latter (as archeobacteria; see Glossary, entry Archaea) are unanimously recognized as having appeared very near the root of that tree.

Taking for granted the contention of Grassé that "bacteria have evolved very little since their appearance", and, more specifically, that E.coli are "practically stabilized since a billion years ago" (p.87), it is perhaps more than a futile speculation (although, admittedly, still unsufficiently substantiated here), that those bacteria and amoebae had this kind of intelligence already at the earliest stages of their existence (possibly to a somewhat lesser extent than now). The extension to other primitive animals is straightforward; bacteria and amoebae are not 'super-smart' beings in comparison to the millions of species at these levels.

These few examples, I must stress, cannot (and are not intended to) do justice to Kropotkin's and Dawkins' exciting accounts, much less to the richness of nature itself. They are intended solely to serve the purposes of the present work. At the moment it is: to make it quite clear, that free intelligence is pervading animal life in all its diversification; and that, in all appearance, it is the tool used by animals in consciously performed acts.

Let us cite Kropotkin's summarizing sentence: "Nature is variety itself, offering all possible varieties of characters, from the basest to the highest: and that is why **she cannot be depicted by any sweeping assertion**." (p45; my emphasis, which, I believe, cannot be strong enough).

When we compare the respective definitions of intelligence and instinct, it transpires that there is no clearcut borderline between them, especially in what concerns '*learning*' (an attribute of free intelligence). "Birds have the instinct to learn to fly" (Oxf Adv. Learn. Diction. 1989); and: " ... fixed [instinctive] action patterns that may be modified by learning processes ... ; ... by trial and error" (Encycl. Brit., Micropaedia 1985).

J. Alcock, an authority in the branch of Animal Behavior, states that "innate predisposition to learning has been confirmed in quite a number of animals, and may be it is universal in living beings" (Alcock 1979, p.58).

This expresses clearly the smooth transition from the innate (the instinctive), to the acquired (learnt).

"The instinct to learn" says, in other words: "the instinct to exert free intelligence" (since learning is enacted and steered by intelligence in the usual sense, whereas instinct is "without having to learn"). This characterization applies also to man! Although almost instinct-deprived, "humans are genetically predisposed for learning" (Ayala & Valentine 1979, p.395). Conspicuously, the youngster has an instinct to learn things, like to stand on his feet and go erect (with example and help of his parents, of course, just as bird-mother shows her nestlings how to fly); and similarly: to think and to ask questions (many many of them!), to play etc.; at a later stage, to plan, build, construct etc. These activities are manifestations of free intelligence.

Again, we can show that this principle applies down to the lowest creatures. For instance, in bacteria "the difference between instinct and learning... becomes a matter of time scale [compare the case made above about 'time delay'], not of principle." (Koshland 1977, p. 1061).

Extensive research work has been done on animal behavior; it is amply documented in the extensive existing literature, including a three-volume treatise **on invertebrate learning** (Corning et.al. 1973). It amply proves, I believe, that 'free intelligence' is widespread in the animal world. [9]

Nature, then, does not make a clear distinction between instinct and intelligence. This fact has been insistingly pointed out by Etkin, who summarizes: "Just as previously we stressed the idea, that the fact that a response appears to be innate [i.e. instinctive] does not preclude the existence of elements in it that depend on experience [i.e. learning], so we wish now to point up the fact that because a response is commonly considered as learnt, this does not mean that large elements of it are not determined or restricted by innate factors." (Etkin 1964, p.189). An impressive example that demonstrates convincingly this state of affairs, emerged from the behavioral study of the whitecrowned sparrow (see, e.g., Alcock 1977, p.70ff). The male birds of this species sing a species-specific song. The young males learn the song from their parents or some of their elder conspecifics (members of their own species); this proves that the information of their melody is not innate. But on the other hand, nestlings that were separated from their conspecifics are unable to learn a song of other birds, although similar to their own. This indicates that the birds have a kind of template in their brain, which accepts into their memory only that melody which "fits" exactly into the template (which is an innate information). Alcock believes that we humans, too, have such templates in our brain (p. 73). This would mean, that there are inherent limits (in the form of 'templates') to our capacity of understanding! In any case, innate and acquired information are intimately interconnected.

Everyday-life responses to stimuli, then, may be (and probably very often are) the product of combined action of the two kinds of information: innate (i.e. inscribed in the genome) and acquired through experience and learning (i.e. stored in the memory). While the two kinds can be distinguished in principle (through what is genetic and what is epigenetic), we have to bear in mind that this distinction has no well-defined borders; the two domains are deeply interpenetrating.

So far we have verified, I think, that free intelligence and consciousness exist in the animal world. It is my conviction, that this existence had a far-reaching, perhaps even decisive, influence on its evolutionary history; in particular, on the process of natural selection, as far as the latter was at work. We are remindful of the minor role we had attributed to natural selection in chapter I.; yet, the concept of ***'intelligent selection'*** still was not brought up then. No more are we dependent, for selection, on the rare 'chanceful mutations'. The pervading existence of intelligence in the living world (as shown), clearly must have had a positive selective influence on the course of evolution. To what extent, and what the consequences thereof are, we would like to discuss in the sequel. (Consciousness will be discussed in chapter VIII).

Most important for mankind, - the effects of intelligent selection on man himself. If homo sapiens has survived since his emergence and up to the present, if he has proliferated and spread all over the five continents, it is not thanks to his bearlike muscles (which he has not), nor to his monkey-like agility or gazelle-like speedy running (which he is not endowed with). Nor has he the hawk's eyes or a dog's ears and scent. It is solely thanks to his immensely superior intelligence that he not only survived and proliferated, but also became the dominant living creature on earth. "Dominant" is an understatement! The influential biologist-evolutionist (anti-creationist) DJ. Futuyma states: "There exists an **unbridgeable gap** between humans and all other animals in cognitive abilities" (Futuyma 1998; my emphasis).

Thanks to this intelligence, he was enabled to fulfill the order of the Torah: 'פרו ורבו ומלאו את הארץ וכבשה ורדו בדגת-הים ובעוף השמים וגו' (בר' א כח)

"Be fruitful and multiply; and replenish the earth and subdue it; and have dominion over the fish of the sea and over the fowl of the air and over every living thing ... " (Gen. 1,28).

In fact, man has achieved domination of both the inanimate and the living world on earth; already he stretches out his hand to other celestial bodies! (We shall speak of this in chapters VII & IX). Man has changed dramatically the ecological equilibrium which was to be expected in his absence (he even "managed" to exterminate, nearly or completely, many animal species). Mankind is a striking example of pushing forward evolution without major changes in gene frequency. Evolutionists consider 'change of gene frequency' a yardstick for measuring evolutionary change. The philosopher of biology Elliott Sober contests the correctness of this definition (for reasons that are not our concern here). Yet, he raises the question, whether "the mere change in the number of organisms a species contain" should not also be considered an evolutionary change, in view of the great ecological significance such change in number can have. He states: "Change in gene frequency covers one type of [evolutionary] change but fails to include others" (Sober 1993, pp. 3-5). In the case of mankind, the change in number of individuals was such as to change dramatically the earth's whole biosphere! And this, (to a most significant extent,) through nonheritable skills, that were acquired, socially transmitted, and exploited in the multitude of man's endeavors. We all know, that our achievements are due, not simply to the size (or weight) of our brains as such, nor to our innate instincts, but to what we have learned from our parents and teachers and, of course, to our own experiences, our thinking, trying, imaginating, etc.; the successes of these we, in our turn, transmit to our children who, in their turn, will improve on them. Tradition is perpetuation.

Man is, no doubt, the most striking proof for the workings of ***intelligent selection*** in evolution.

An important factor in both animal and man is the selective value of sexual behavior. This has been recognized at an early stage of evolutionary theory. Darwin called it "sexual selection". In the animal world, its main driving forces are: 'male competition' (improved chance of the more vigorous, or the more aesthetically attractive, to get a mate and reproduce), and 'female choice' (giving preference to the males with the better scores). Intelligence was at work here, too! [7]

As for man: at the present time, research on scientific pairing of marriage candidates is currently underway at the University level. This might prove to be a further step on the road of 'intelligent sexual selection'. Yet, this is a road which, no doubt, the human society has been walking-on, both consciously and unconsciously, since ever.

Bronowski, in his much-read book "The Ascent of Man" (paraphrasing Darwin's "The Descent of Man"), writes:

"We, the hominids, must have supplied a form of selection of our own"; and he adds: "selection for skills has always been important on the part of both sexes." (Bronowski 1973).

Intelligent selection, without doubt, is widespread also in the animal world. For the 'higher' animals we can take into account, that instinct (innate intelligence) and 'free intelligence' are intimately interconnected; yet, intelligent selection can easily be traced back farther into the animal kingdom, even where 'free intelligence' is lacking or, at least, cannot be ascertained.

One of the instincts, in very many species, is imitation.

"Birds have the instinct to learn to fly"; this is done mainly by imitating the mother. Other animals also, as youngsters, have the instinct to learn things by imitating the adults. So, e.g.,"young rats tend to take their first meals of solid food in the vicinity of an adult and thus to ingest the same foods as the adults" (Galef-Clark 1971). Also, "rats under natural conditions have a tremendous exploratory drive, which leads them to explore every new aspect of their territory."... "The biological usefulness of this knowledge becomes apparent when a predator, ... , appears." (Etkin 1964, p.185). Here too, probably, the youngsters learn from the adults "dashing for the nearest hiding place without the least hesitancy or circumambulation", thanks to the knowledge gained in the prior exploration.

A property in social behavior where the practice of imitation is at least plausible, is "Dominance hierarchy", i.e. a kind of rank order within an animal population, lending prerogatives to a "superior" over its "subordinates". Since "communication is the essence of all social behavior" (Dewsbury 1978, p.99), it seems natural that a superior will have some influence on the behavioral patterns of its subordinates also in the sense, that these will tend to imitate the "leader". Dominance hierarchies have been observed in chicken (the "peck order"), as well as in certain species of crabs, crayfish, cockroaches, lizards, rodents, etc. (l.c., p.93). As it is well known that these animals have very highly developed instincts, it should not be surprising that thanks to these, they are very clever in learning from their parents, or from other adults, by imitating them or by other means (e.g. by observing casualties, and learning avoidance). We see, then, that animals, even those we use to call 'lower', learn from experience and transmit learnt skills to their descendants. Needless to say that (in the mean) better learning, better imitating, grants a selective advantage .

The kinds of behavior just exemplified are commonly classified under headings such as "social" or "cultural" or even "sociocultural evolution". That very many animal species conduct a social life is undeniable; both innate and free intelligence are at work here. (The use of the term 'cultural' is somewhat controversial [8]).

If, in fact, intelligence (innate and free) is pervading all of life, it must have had a profound influence on the evolutionary process. Seen its antiquity (as we have tried to show up), it must have been a force that drove the evolution of life from its beginnings on. And we return to the question about the sources of intelligence, in its three modes of expression.

The seat of 'free intelligence' is obviously the brain, that mysterious organ whose deep secrets are still essentially unexplored. (Chapter VIII. will treat of some of its aspects). Here, we shall restrict ourselves to try delving into the problem of the sources of 'innate intelligence' and, more generally, of molecular information.

A first possible source relates to an issue that, still today, raises a controversy of long standing. It goes about the question, whether traits that have been acquired by an individuum during lifetime (and 'culturally' transmitted) can (or cannot) turn inheritable in the course of time. Its paradigm is: the long neck, and the long forelegs, of the giraffe. These are assumed, by the supporters of *'heritability of acqired characters'*, to have reached this funny length by virtue of the efforts, made by a long· series of predecessors, to reach to higher and higher branches for the sake of more efficient browsing. The anomalous-looking length is no doubt a heritable feature; the question is: did it evolve thanks to the sustained efforts of many generations of giraffes?

The classical proponent of 'heritability of acquired characters' was the great pre-Darwinian, 18th century biologist Jean Baptiste de Lamarck. Known today as 'Lamarckism', his theory of transformations ("transformism"), is a special kind of evolutionary theory, radically different from conventional Darwinism. It made the subject of ardous discussions as soon as the latter gained influence. Eventually, it got almost abandoned; "Lamarck did not know how to dramatise his views for a wider public"; (Encycl. Britannica). However, in recent years, Lamarck's ideas appear again, sporadically, in various forms of ***'neo-Lamarckism'***. This is so, perhaps, because the general underlying idea is intuitively appealing. For instance:

The cradle of homo stood, (as conventionally accepted), in the tropic zone. The black skin color evolved, presumably, as a protective reaction (an 'adaptation') against the intense sunlight. However, it eventually got into the genome of black people, such that their children are born black;

and probably the inverse process ocurred in people whose ancestors had wandered to the cold zones. (The alternative explanation, based on ‘survival of those with the right chanceful mutation’, seems less convincing).

Pritchard **suggests**, that “acquired characters **could**, over a long period of time, be brought under genetic control”. (1986, p.314-5). Moreover, it appears that, at least for a restricted class of so called “polygenic characters” (i.e. characters that are controlled by more than one gene), there is wide agreement that they contain an environmental component, (meaning, that experiential factors influence the genetic constitution) (Ridley 1993, p.216).

A number of authors, in the last few years, have dedicated serious work of research to the elucidation of factors that could enable somatically acquired cell characters to penetrate the ‘Weismann-barrier’ (Prichard 1986, p.80). It is conjectured, that it could be brought about by getting expressed, first, in the genome of a thus altered somatic cell, and therefrom, in very sophisticated ways, into the genome of a germ cell. A research conducted by E.J. Steele and co-workers has (it is claimed) “uncovered strong molecular genetic evidence that aspects of acquired immunities developed by parents in their lifetime can be passed on to their offspring” (Steele et.al.,1998, back-cover). This research penetrates into the wondrous ways of our immune system, in combatting body-alien substances (such as bacteria and viruses; but also transplants, as well-known). The researchers focus on the phenomenon of acquired immunity against certain infectuous diseases, occuring either naturally (after a first infection), or by vaccination. The body, in such cases, retains a memory of past infection. It is plausible, that this is achieved by inscription in genetic stuff; the researchers assure that it is.

Although this research, thorough as it may be, concerns only a very special case, the authors believe that factually a Lamarckian principle operates in a much wider field. They construe it in the form of a *‘soma-to-germline feedback loop’*. (The term ‘feedback’ applies here, because the mainstream direction in ontogeny is from the germline to the soma.)

Analogously to the above example of skin color, the authors mention the adaptation of certain leg bones to the type of squatting, people of different origin are accustomed to. It has become inheritable. Some other features are brought as well, as examplifying acquired traits that got heritable in time.

The authors contend, to have "**solid reasons**" for introducing a "**distinctly neo-Lamarckian concept** into contemporary evolutionary theory"; namely: the factual "direct penetration of 'Weismann's Barrier', in the case of some [immunoglobulin producing] multigen families" (l. c., p.179; my emphasis).

We note in passing, that if all this should prove correct, it could turn out that evolution proceeded **quite differently from what darwinistic theories depicted**.

Returning to our question: In the measure that "heritability of acquired characters" has been realized in nature, the 'bound' intelligence stored in the genome is partly traceable to life-experiences that shaped the acquired characters in former generations, whatever the (as yet unknown) process leading to their embodiment in the genome might have been. This part, then, originated in the evolutionary process by either instinctively or intelligently directed effort to acquire certain useful traits, acting on the genetic constitution that determines morphological or other characters.

Whatever the importance of this kind of contribution to the existing extent of 'innate intelligence' may be, there can be no doubt there must exist a source of incomparably greater importance that explains its universal presence in living beings. Life displays an endless plethora of genetic information of the subtlest kind that cannot be traced to experiential acquisition of favorable traits, the Lamarckian way.

In consequence, we are left with the crucial question: how did the genetic instructions that make us think of as being implementations of 'good ideas', but not possibly stemming from their owner's intelligent efforts, get into the genes?

We should be aware, that the mystery lying in the existence of these "good ideas" is not restricted to the genes. They pervade all components of living matter. For the interested reader, we shall present some deeper look into this ‘world of marvels’. These marvels, I take the freedom to call “good ideas” (suggestive of design. I hope to be excused for). These will be the subject-matter of the next chapter.

In order to give here just a clue as to what is spoken of, let us focus on the genome, this most representative body of genetic information, at the stage when it is contained in a minuscule fertilized ovum (egg-cell). It contains the complete set of informations of:

a.) how to build up the mature organism, in all the details of its various organs and organelles;

b.) how to manage its household, its balance (homeostasis), its metabolism;

c.) how to combat invaders (bacteria, viruses, etc.); that is: how to organize its immune system; how to synthesize the required antibodies, etc., etc.

Every member of any given species possesses such a genome, in myriads and up to trillions (in humans) of copies. It is contained in every single cell of its body, even in the roots of the hairs. Different species, forcibly, have different genomes. And there are (and there have been, now extinct) millions over millions of different species. Indeed, a huge amount of genetic information (that is: of ‘innate intelligence’) embodied in living creatures.

The laconically short appreciation, made here, of the wealth of information stored in genomes, by no means does justice to the immensity of the factual extent of an organism’s information content. The inner workings of any single cell, of any kind, is concerted by the instructions emanating :from the genes. This activity is full of marvel and mystery. And no less so is the interplay between the cells constituting a body. This is true for the part already unveiled; the part still concealed from our knowledge can hardly be less so. We are left, then, with the, as yet unsolved, problem: how did the “good ideas” (truly: the marvels of nature), so overtly manifest in living stuff, get into the genes?

Before trying to expose our answer, it is perhaps in place to choose a term that fits the character of evolution as exposed here. Tracing all the contributing factors mentioned above to a common denominator, it seems to me appropriate to refer to the natural history of the biosphere as to "Intelligent Evolution" (meaning: evolution driven by intelligence, innate and free). In other words, what we have called earlier "intelligent selection", is that major part of natural selection, that contributes to 'intelligent evolution'.

'Intelligent evolution' is an antithesis to the (still!) accepted view of 'chanceful stochastic evolution'. In informal parlance, one can express it thus: "Good ideas" are at the root of progress in evolution; they are stored in the genes. The latter either underwent changes or evolved de-novo in the course of evolutionary history to produce new, better ideas. These are implemented, via the genes, in the whole organism.

In those living things where intelligence is present solely in the form of information stored in the genome, and perpetuated by inheritance, the great question is (as said): how did the "good ideas" get into their genomes. By the arguments presented in the preceding chapters, we have already rebutted the darwinistic ('teleonomistic') thesis, that "Lady Luck" could possibly have introduced them. What else, then?

But: Why is all this important to us? In chapter VII. we shall try to give an answer to both of these questions.

Notes to Chapter V.

Note 1. It is not at all easy to define that 'something more', supposed to form an important part of (at least) human intelligence. Even the definition of the simple-looking concept of 'learning' presents difficulties. Corning et al. (1973, p.1,ff) pass 'en revue' a number of definitions, as formulated by several researchers in the field of animal behavior, every one of them defining in his own way and conform to his own personal conceptions. Thereupon, Corning et al. prefer to dispense altogether with a technical definition of learning, using instead "the more neutral and descriptive phrase '*behavioral modification based on experience*' ". Their "domain of interest" lies in "a change in behavior (response, output) as a function of characteristics of the events which have preceded that response when it occured on previous occasions". Clearly, a concise definition is better to be evaded.

According to this formulation, **any** consistently observed response (in said circumstances) testifies to learning. I would consider it preferable, to consider only those responses which are of nature to improve the "quality of life" of the responding organism, worth being called 'learning'. To learn is learning to do better, not also to do worse. I think that anyway, as a matter of fact, learning in the general sense of Dyal & Corning almost always elicits responses that are favorable to the animal's life. This is so both in natural and in experimental learning situations. Such kind of learning, precisely, is the hallmark of intelligence (i.e., of what we call "free intelligence").

As to the 'something more' alluded to, it refers specifically to human intelligence. As it is a subject of subtle kind, we shall return to in chapter VIII.

Note 2. The sentence "The answer is too obvious..." has been omitted in the 1996 edition. Except for this, the passage remains essentially unchanged.

Note 3. Of course, others have described animal life and animal intelligence, in their respective areas of interest, with comparable eloquence. A rich, modern literature is available. The list of 'Further readings' below lists only a very few older classics.

Note 4. The ants have been characterized by some computer-minded writers as "soft automata", or "chips on feet". Let us see, what these chips are capable of.

Ants sow, harvest, build granaries to stock the crops, rear aphides (the 'cows of the ants') to enjoy sucking their secretions. They build "wonderful nests" (buildings of size relatively larger than man's!), paved roads, vaulted galleries and spacious halls. They live in large colonies; and they work in diligent cooperation to achieve all this. These are well-known facts. But there is more to tell about them (mainly taken from Kropotkin, p.29,ff).

Colonies of ants, at times, form together what can be called an 'ant-nation', which may comprise the inhabitants of more than fifteenhundred nests (p.33). As such, two nations often happen to be enemies (how not?). The battles they fight are extremely cruel. An observer who once saw "two teeming colonies of leaf cutter ants fighting", examined the battlefield and found it strewn over and over plucked feet and mutilated bodies. The view deployed to his eyes was comparable to the famous "limb-strewn battlefield" paintings of Passchendaele. Yet: "However terrible the wars between different species, and whatever the atrocities committed at war-time, mutual aid within the community, ... , and very often self-sacrifice for the common welfare, are the rule." (l.c., p.30). Regurgitating food, in order to feed a hungry comrade, is a prominent feature of ants. An ant that has its crop full and refuses to feed "will be treated as an enemy, or even worse".

But the summit of the ant's behavior is, I believe, the following: "If an ant has not refused to feed another ant belonging to an enemy species, it will be treated by the kinsfolk of the latter as a friend." Magnanimity of ants!

And Kropotkin stresses: "All this is confirmed by most accurate observation and decisive experiments." "Chips on feet", really?

Quite generally, for insects, it has been confirmed that the "... belief that insects are 'hard-wired' automata turns out to be wrong" (Bialek 1997; p.264). ['Hard-wired' means that the behavior is completely instinctive, as determined by the inherited genetic stuff. It can not be altered by learning, just as a computer's wiring cannot.]

The authors exemplify their verdict by an interesting experiment: Flies, having an electrode implanted in their brain, are shown 'movies' on a screen. It is found, that "... the fly's visual system can extract an estimate of motion down to the limits imposed by diffraction [i.e., by physical law], .,. and then encode this estimate... , and uses what it knows to adjust its computations" [for adjusting its motion to the environment encountered].

No doubt, an impressive demonstration of an insect's ability to cope with unusual situations! And, hard to believe: the fly even shows a "preference for 'looking at' novel patterns" (l.c., pp.265-66).

Note 5. Probably they have not; Pierre Teilhardt de Chardin, the monk-biologist who has impressed so many openminded people by his scientifical-visionary sight of evolution in past and future, has expressed this concisely: "Admittedly, the animal knows; but it cannot know that it knows". Certain ethologists (researchers in *Animal Behavior*) have seen signs of a rudimentary self-consciousness in the observation that some apes groom themselves in face of a mirror. However, Richard Byrne, a very careful observer of primates' life, and investigator of the connections between animal behavior and mind, infers from the defective behavior of apes in front of a mirror that "their idea of 'self' probably differs from a human one" (Byrne 1995).

Note 6. Skeptics still might argue that these small animals are nothing but little robots, devoid of consciousness. Even if that were true, it would be of no concern to us. If robots, they are robots designed and constructed with unbelievable ingenuity. We would have to join them, then, to all the other marvels of nature presented in the next chapter. Yet, in view of what has been known of their activities, the contention of robotic action seems absurd.

Grassé relates still another remarkable observation made on amoebae, “the simplest of all animals”. Amoebae of the species Arcella, when accidently fallen on their back, try to use their long pseudopods in an attempt to turn themselves into their normal position, back upwards. More often than not, these efforts do not succeed. But the animalcule does not despair; it secretes a bubble of gas, which displaces the center of gravity, enabling the pseudopods to complete their action. Grassé remarks, that this adaptive reaction of the amoeba is non-heritable. While perhaps not yet a convincing indication of intelligence, this deployment of efforts shows at least clearly, that the urge of self-preservation is strongly developed already in this most primitive living thing.

Note 7. A famous problem (“a long-running puzzle”), raised in evolutionary theory is the conspicious, yet apparently disadvantageous, feature of many male animals of exhibiting a clumsy and obviously tiresome appurtenance (generally believed to serve the purpose of attracting females). The paradigm thereof is the peacock’s tail. Of the two classical attempts to reconcile this apparently counter-evolutionary phenomenon with darwinistic theory, that of the Israeli scientist A. Zahavi (“Zahavi’s handicap theory”) is illuminating. It is based on the supposition, that a female will give preference to a male that proves its vigor by the very fact of thriving despite the unreasonably heavy burden. Indiscriminately, the burden may be a presumptuous tail (as in the peacock) or a host of parasites plaguing the male.

These female peacocks must be very intelligent; shrewd, indeed!

In any case, there can hardly be any doubt that female animals can be impressed by such bodily pomp, as exhibited by males. A striking confirmation thereof has been given in a cleverly conducted experiment, done with a certain species of fishes. The tail length of their males was markedly varied, and it had been observed that the females preferred those with a long tail. Thereupon, a number of short-tailed males were subjected to a ‘cosmetic operation’, fitting them with a conspicuous long tail. Put back into their natural environment, their heightened attractivity to females was unmistakable. (A similar, even more surprising case will be brought in chapter VIII.).

This is only one example out of all those that incite scientists to ascribe to animals an urge to follow a "highly abstract esthetic rule" (see Preface).

Note 8. M.S. Dawkins, too, expresses reluctance from a general use of the term 'cultural' in the context of animal behavior (Dawkins 1993, p.45).

Note 9. Some time after I had written this chapter, I came across the book: "**Animal Traditions**; Behavioral Inheritance in Evolution", of two Israeli scientists, E. Avital and E. Jablonka.

Their thorough and erudite treatment of the subject substantially covers what I have written on it up to this point; a welcome confirmation, that the ideas about this subject (as noted by the authors, their essence is not new), are beginning to gain acceptance in the scientific community. (May I perhaps hope the like for further ideas of the present essay?)

I should acknowledge that, going beyond what I have said, the authors advance an innovative concept that could uncover an important factor active in evolution: a self-amplifying force (kind of positive feedback) inherent in behavioral inheritance. The effect of such a force would naturally have driven this kind of epigenetic evolution at a pace much higher than expectable without it.

In the authors' words: " ... , we are going to argue, that the evolution of learning is, to a large extent, self-propelled".

However, no role is ascribed by the authors to (free) intelligence, in driving evolution.

Further Readings

Alfred Edmund Brehm: **Brehm's Tierleben**, Vol. I - XIII.
Bibliogr. Institut Leipzig 1930 - 1934

Auguste Forel: **Recherches sur les fourmis de la Suisse** Vol I., II.
Zurich 1874

The social World of the Ants (transl. by C.K.Ogden)
G.P.Putnam's Sons, Ltd London 1928

Pierre Huber: **Recherches sur les moeurs des Fourmis indigènes**
J.J. Paschoud, Paris 1810 Geneva 1861

Jean Charles Houzeau**: Les facultés mentales des animaux**
Buechner, Bruxelles 1872

Chapter VI: A world of marvel

In preparation to answering the question posed at the end of the previous chapter, let us first delve somewhat deeper into the mystery of life. This will help us grasp more fully the significance of the answer.

Mystery, life will probably remain forever. Yet, we are able to disclose many of its marvels. This has already been done to such extent, that a serious scientist has used the metaphor of a mechanical clockwork encased in transparent plastic. We can see clearly how the intricate mechanism works; "we can explain it, but we cannot understand it." (Hunter 2000, p.344). We cannot, because our explanations, including the most sophisticated ones, inevitably lead us to mystery. In the deep ground, it always **is** mystery! In the case of the clock: What are these mysterious electrical forces in nuclei and electrons, that both keep the atoms together and keep the quartz crystal lattice in vibration, with a precise frequency stable for months and years?

The nature of electricity is unfathomable. Electricity is a **mystery** that pervades the whole universe. It is buried in very nature of matter. Life is mystery of another kind; one consisting of many strata. A relatively easily accessible stratum is its molecular basis. It has been fairly well uncovered in the last few decades. Does this make it 'understandable'?

The "elucidation of the molecular basis of life has in no way diminished **- perhaps even enhanced - the sense of wonder, Darwin had expressed so lyrically**" (l.c., p.343; my emphasis). To Erwin Schroedinger's famous question: "What is life?" the answer given still today is: "…**the essential nature of life continues to elude us**" (Harold 2001, p.7; my emphasis). This answer is all the more trustworthy, as it is given in the context of what could be called 'a cry of distress of the atheist' (such as the uttering, that it is "not at all self-evident that, absent a belief ... , a decent and civilized society can be sustained for long" (l.c. p.255).

In order to give the reader a feeling of what the metaphor of the transparent clockwork, (explainable but incomprehensible), wishes to convey, the topic of "good ideas", touched upon in the preceding chapter, is worth some further exemplification.

It is not the scarcity of examples that makes this task difficult. Rather, it is “l’embarras du choix”. The tiniest speck of living matter holds mystery of some kind.

Two sources for discovery of ‘good ideas’ are at our disposal: The way of life (‘behavior’) of living beings, and the machinery of their organisms. Both sources are almost, if not factually, inexhaustible. In nearly every physiological process deep wisdom (seen from the human point of view) discloses itself to the scientist.

Of course, we could begin with the two most elementary “good ideas”, which are anchored in the basic drives of life: feeding and mating. Bacteria already do that! The first appearance of the bacteria is believed to date around two billion years ago. So, this couple of most basic drives, (i.e., self-preservation and reproduction) necessarily have existed already at that very early stage in evolutionary history.

The kinds and manners in which ‘nature’ has implemented these two fundamental drives, are almost infinitely variegated. We could speak of the spider, which has ‘invented’ the net, long before man, for catching its prey; of the ant, having practiced agriculture long before man; of the bat, which has ‘developed’ the sonar (ultrasound radar) long before man. The famous investigator of communications in animals, Norbert Wiener, has created the science of ‘cybernetics’ (comparative information theory), inspired by the wealth of ‘good ideas’ he found implemented in the animal world.

In the anatomical and physiological domain one could speak of the sheer endless series of amazing processes taking place in ontogenesis, from gastrulation (the forming of the digestive tract in the early embryo) to the intricate weaving of the brain’s neuronic network. Scientists do not cease to wonder how the growing nerve fibers find their way, through the neuron-web already grown, to their right final place in the (neo-)cortex. Not to mention the extremely ingenious design of the sense-organs, and their exquisite performances.

There can be no question of providing here, even roughly, a comprehensive account of the ‘good ideas’ embodied in life, impressive though they all are. We must confine ourselves to very few of the especially subtle and sophisticated kinds. I chose some examples that have struck me most particularly, and that are less likely to be presented by the media.

Some are chosen from the realm of animal behavior, others from the inner workings of living stuff. As for the latter, their ingenuity lets them appear as if they were the brain product of an unbelievably intelligent designer. Should the knowledgeable reader find my exposition all too meager, I agree beforehand, and I present my apologies to him and to Whom grants life to all that is alive; life with all its splendor and all its awe.

So, let us make a short excursion into an exciting domain: Sex.

We have touched upon it already in note 2 of chapter I., in connection with one of the greatest (if not THE greatest) unsolved problems in evolutionary biology: why is sexual reproduction so widespread in the whole living world?

The question asked is not so much: why did sex evolve at all? Rather, the question debated in sheer unending discussions between experts is: Given that it once appeared, in some form, by ‘blind’ (i.e., purposeless) evolution, why did sexual reproduction not revert (through ‘almighty’ natural selection!) to one of the several possible forms of asexual reproduction, or else, to *parthenogenesis* where (despite its being classified as ‘sexual’) a new individual is born out of a **self-fertilized** egg.

That **this** question haunts the minds of evolutionists (rather than: why it exists at all), is not trivial. Clearly, from the start, Darwinian evolution was in need of a plausible explanation for why sexual reproduction arose in the first place, and what justifies its success in gaining preponderance. In fact, from an evolutionary standpoint asexual reproduction is both simpler and more efficient than sexual. The sexual kind of reproduction is ‘costly’, evolutionarily speaking. Firstly, it has to pay a ‘50% price’: two individuals are required for producing progeny; one female, self-fertilizing its eggs, would suffice. Then, the apparently superfluous male takes its share in the food supply, reducing thereby the chances for survival in times of scarcity. For these and other reasons, Darwinian evolution was initially in trouble. Natural selection, according to the Darwinian principles, should have favored the spreading of the lytokous (male1ess) species, of which quite a number in fact exist today (about a thousand species, among them some kinds of fish and of lizards, but no higher animals).

To this question a seemingly plausible answer had been given. The argument brought forth was, that natural selection would favor bi-parental sexual reproduction, because the latter provides for variability within a species. This is in contrast to asexual, resp. parthenogenetic, reproduction, where the offspring is an almost exact copy of the single parent. Variation between the individuals of a species is an important factor in the latter's survival capability. This is so, because in a variegated population there are good chances that, when environmental conditions change, at least a few individuals will succeed in adapting themselves to the new conditions, even though these might be detrimental to the bulk of the population. In order to enable adaptation, something in the genome must change, i.e. a variation is needed. Here, sexual reproduction shows its superiority. As we shall see in the sequel, various exchanges of genes, during arrangement of the chromosomes and their repartitions, take place before a fertilized egg is formed, leading to genetic variation.

Moreover, it is under such circumstances, in the presence of particularly harsh conditions that a new species may emerge, with more robust and vigorous offspring. As will be remembered, it is held by the classical theory that speciation, i.e. the birth of a new species, is often initiated by some drastic change in the local environment. Such a development would represent a positive step in evolution.

This argument, brought forth by Darwinists, was seriously criticized (as outlined in note 2 of chapter I.), on grounds of the inherent 'shortsightedness' of Darwinian evolution. This concept of evolution denies the ability of 'natural selection' to preserve 'future interests' of a species.

Besides, the argument has lost much of its weight since drastic environmental changes have become rare since long, while a very considerable number of species have reached an already high level of adaptation to their respective environments. Therefore, natural selection should be expected to have used any opportunity, in the form of 'favorable' mutations, (purported by the Darwinists to occur so plentifully, indeed, in order to explain the rich existing 'gallery' of perfectly well-adapted forms of life!), for reverting to asexual or parthenogenetic reproduction. It should occur even in the most highly developed taxa. Yet, it did not occur, (save some rare exceptions)! There still remains "an outstanding puzzle" in evolutionary biology.

The riddle is brought to a higher potency by considering that, as a matter of fact, a first step (a major one!) towards return to asexuality actually **does** take place, regularly, in every mature individual of a bi-sexual species. Every individual possesses since its infancy special cells, the germ cells [1a] , destined to become gametes (spermatozoa in the male, egg cells in the female). In the process of gamete formation, called '**meiosis**', Nature brings about (in a sense) a 'return to unisex' (that is: to a germ cell that could develop into an asexually reproducing being).

As explained in chapter I., the cells of multi-cellular ('higher') organisms are 'diploid', i.e., they contain, each, a double set of chromosomes. This is the case also for the germ cells, until they undergo the process of '***meiosis***'.

Meiosis is a special kind of cell division. It produces, from the diploid germ cells, haploid (single set) cells, *gametes*. This return to haploidy {which is the archaic cell type, still extant in the single-celled organisms) could have been the first step, should 'evolution have chosen' to revert to asexuality [lb].

It is important to realize (as one of today's leading geneticists writes), that the Darwinian evolution of meiosis by natural selection, "must have been an extremely demanding process" (Maguire 1995, p330). We will convince ourselves thereof later-on in this chapter. Yet, this step has in fact been accomplished! It is, so-to-say, 'built-in' into sexual reproduction from the start. "A spectacular achievement" it is calIed by Maguire (l.c.). By contrast, once this step done, producing an embryo asexually would have been "a relatively easy achievement". It would only have required a mutation that would let the process proceed with self-replication of the haploid genome, making it a diploid. In the uterus, this cell would have full the potential to grow up into a mature individual, a clone of its mother.

But at this stage, 'Nature' says: **STOP**! No continuation on the road to asexuality; back to sexual diploidy! In place of self-replication, the restoration of the diploid state will eventually be effected (as well-known), through fertilization of an ovum by a spermatozoon. The latter intrudes into the ovum, and delivers the paternal haploid genome it carries in its head [2].

In light of this 'near-pass' at asexuality, our original question, why did natural selection **not** lead from sexual to the (from the point of view of

Darwinian fitness) more advantageous asexual form of reproduction, gains substantially more weight.

Additional weight is provided by the factual induction of parthenogenesis, occurring in the animal world. The parasitic bacterium *Wolbachia* induces it in its bi-sexual hosts. **'By chance'**, Wolbachia parasitizes only insects. Taking into account that the genetic stuff of insects has much in common with that of humans, the words put between marks in the former sentence should set us thinking.

Having thus (hopefully) gained full awareness of the dilemma that intrigues Darwinian evolutionists up to the present day, let us restate it concisely: Taken for granted, that Darwinian evolution once produced sexuality by some arcane stochastic mutation, why did sexual reproduction spread and thrive, despite its apparent high cost (in evolutionary terms), instead of reverting to a "more rational mode of reproduction". Ridley states (eight years after his 1993 book): "Sex is a puzzle that has not yet been solved. No one knows why it exists" (Ridley 2001, p.lll); "…it is far from obvious" (p.l08). Attempts to answer this question have been made; we shall see two of them in a moment. Yet, a convincing solution to this "outstanding puzzle" has (as far as I am aware) not yet been given by science.

Our sages, implicitly, gave an answer, as we have seen in Note 2 of chapter 1.

And then comes one of them (an authority in evolutionary biology!) and proposes THE solution of the riddle: The mutation required for this reversion to asexuality "simply did not occur"! How convenient!! After all we know about the immense plethora of mutations that shaped evolution, should we believe **that?**

(Yes, we should! Because there is a **Will** that **this** mutation should not occur!)

A further question raised in evolutionary theory was why, almost universally, the sex-ratio of progeny is 50% (that is: in the mean, equal numbers of males and females are born). Seen that one male is capable of inseminating many females, it would seem from an evolutionary standpoint that an unsymmetrical sex-ratio would be a fitter trait than the 50% ratio.

It required the genius of RA. Fisher (of the trio Fisher-Haldane-Wright, founders of the “synthetic theory”, i.e. of neo-Darwinism) to furnish the proof that the 50% ratio is the point of equilibrium in the “struggle” of the individual female for highest fitness with respect to offspring production.

So far so good; but there are life-conditions where this rule (that a 50%-ratio is optimal) does not apply. This is the case, e.g., when there is only “*local mate competition*”. What would females do in such situations? Well, cases are known (e.g., of mites), where the female has an evolutionarily adjusted optimal male/female ratio of her eggs, that is different from 50%. But really remarkable is the case of that curious species of parasitic wasps, whose females lay their eggs into living tissue. These females adjust that ratio, from case to case, according to the situation they actually encounter in the parasitized host. They are able to do this, because of two peculiar traits, they possess: Firstly, when **males are rare**, they self-fertilize. In addition, their ovipositor (egg-depositing organ) is at the same time also a chemical sensor (a “good idea” in its own right!). When such a female finds its host already ‘honored’ by the eggs of a former ‘lady visitor’ wasp, she deposits male-sexed eggs in greater-than-normal proportion. This is just, what the “local mate competition” theory (formulated by W.D. Hamilton), would have predicted for this special case! ‘Nature’ has done it again!

Such fine instinctive **ad-hoc** adjustment of an evolutionarily predetermined and, no less properly, “calculated” sex-ratio might well be suited to serve as a paradigm of “**innate good ideas**”, stored in the hereditary stuff of living beings. To invoke here “cultural transmission” of an idea produced by “free intelligence” (as we had with Imo, in Ch.5) seems absurd (although we cannot really know!).

Let’s consider another good idea implemented by insects.

As universally acknowledged, reproduction is a central goal of any living being. In the opinion of most evolutionists, what counts most in the “struggle for survival”, is “the good of the individual”, i.e., the fitness for enabling it to insure its **own** ‘{survival + reproduction}’, otherwise said: to insure the **survival of its own genes**.[3] . Now, the males of a number of insect species (wasps, beetles, butterflies, etc.) had the good, yea, ingenious, idea how to do this: after copulation, they prevent rival males from mating with “their” female, by “sealing” the vagina with a “glue” they secrete. As if this were not astute enough: there are those wasps that rape their fellow males, obstructing their penises with glue!

Would teleonomists maintain that 'blind', accidental genetic mutations produced these amazing adaptations? Do we not rather have to ascribe them, again, to those "highly abstract" epigenetic rules, already dealt with at the start? [4]

But not only epigenetic phenomena of mysterious origin, manifesting themselves in the behavior of animals, have come to our knowledge. Probably the most superb manifestations of marvel and mystery are found in the inner workings of the microscopic vital stuff. One cannot read a textbook of cell biology or of genetics, without being overwhelmed by the unending series of stunning achievements of the bio-molecular material. We have already spoken of the (purported) arcane coming into existence of the first genetic material, i.e., of the DNA molecule (Crick's "frozen accident"); as well as of its peculiar property of self-replication. Let us now see its activities within the nucleus of a living cell. Primarily, its task is the production of the main building materials of the organism, the proteins. Most of the genes, aligned as they are along a DNA molecule, initiate the production of proteins ("0ne gene, one protein" was once the slogan.) Some of the proteins are enzymes (catalysts); others are the 'structural proteins', building-up the body.

How such proteins were once concerted to build up the first living cell, only G-d knows! (I say that literally!) In any case, this first cell was clever enough (it had the "good idea"!) to duplicate itself (perhaps by cell division, as cells do nowadays). Necessarily also, it had to 'remember', before dividing, to replicate its genetic material, so that each one of the couple of new cells (the 'daughter cells') should have its genome. From where the proteins required for carrying through these activities came, is a genuine 'chicken-and-egg' problem: which came first?

Returning to actuality, let us take a closer look at **how** nature factually operates in the 'entrails' of living stuff (that is: within living cells). Let us see how intricate and, at the same time, how precise and immensely sophisticated the biological, molecular-mechanical and chemico-physiological procedures, used for maintaining life, are. So that we might convince ourselves that, just as the brain researcher William

Bialek expressed this, particularly, with respect to the human brain; so also, quite generally, evolution has not proceeded "in some sort of 'quick and dirty' compromise", (as would be expected in face of the persistent problem, discussed in chapter IV) of: 'was there enough time since the Big-bang, for Darwinian evolution to reach its present high-developed state?' Rather: "evolution has selected mechanisms at the level of the molecule"; mechanisms whose degree of sophistication reaches "the limits of what physical law allows" (Bialek 1997, p.276). One can rightly say that this statement is an understatement when referred to the DNA molecule. Here, it is at the level of an extremely tiny part of the molecule that nature operates with highest accuracy. In fact processes within the cell nucleus operating on the DNA molecule have to be carried out with a precision confined to the minuteness of a 'base-pair'. The 46 molecules of DNA of a human genome contain more than six billion bases (Ridley 2001, p. vii). And even this almost infinitesimal part of a DNA molecule, a base-pair, contains more than a hundred atoms; here, too, Nature operates this way.

An example of much importance is the process of '**n**ucleotide **e**xcision **r**epair' (NER). This is an elaborate organo-chemical operation, performed by the cell on a **definite base-pair**, out of those billions of them contained in the cell's nucleus. An astounding process: self-repair of damage, as occasionally occurs in a chromosome. It consists of the excision of the damaged unit, and its replacement by an intact one. Clearly, first of all, the damage has to be assessed. Therefore, the NER process proceeds on the basis an enzymatic "**damage recognition system**", followed by an "**incision-excision complex**" (a protein complex) getting into action, that removes the damaged unit. The job is completed by "**replacement**" of the excised segment. If the damage affects only one strand (of the DNA-duplex), the replacement is usually done by replication of the corresponding segment in the second strand, and splicing of the replica into the gap. More serious is the case when both strands are damaged. A stretch of double-stranded DNA must then be prepared. The prevailing opinion is, that even this can be achieved by the cell, by making a copy either from a redundant gene in the DNA (if such is available), or from the homologous chromosome (we remember that the chromosomes come in pairs). The stretch finished, it is correctly positioned, and spliced in. (!)

Indeed, an extremely delicate operation, performed at the level of base-pairs. Delicate you say? In all probability, it is also a deeply 'thoughtful' one. In fact, (as we shall soon see), this 'technology' is often used, not exclusively for damage repair. Breaks are produced 'intentionally', both in single and in double strands, by special enzymes (called DNA – Topo-isomerases). One type of them is 'specialized' to produce a single-strand break; another type for bringing about a double-strand break (Wigley 1995). Those breaks (at least according to a widely accepted view) are put to use (amongst others) during that intriguing phase in gamete production already mentioned: *Meiosis* (reduction division). Meiosis will be our main concern in this chapter, because it discloses so strikingly the sublime sophistication of biological processes. We come to it in a moment; First, it is advantageous to recall a few facts about the human genome.

The nucleus of a human somatic cell contains a set of 46 chromosomes. (This set is almost identical in the nuclei of all the cells forming the body of an individual. So, we may speak of a single nucleus, encompassing thereby all of them.) Exactly one half of the chromosomes were inherited from each parent. These two halves are almost identical [5] except for one, which is a sex chromosome, different for the male (looking under the microscope like a Y) and the female (having the usual X-like appearance). The set of 23 chromosomes inherited from either parent, is called a 'haploid' genome. Basically, it contains already the complete genetic information (but see [5] regarding allelic dependence of gene expression). Two chromosomes of the same kind, one paternal, one maternal, form what is termed a 'homologous pair'. (I would have liked to call them "chromosome-twins", being so similar to each other).

The most remarkable component of a chromosome is a thread of microscopic thickness (about two millionths of a millimeter) and of an astonishing (fully-extended) length of up to about two meters (Featherstone 1997). This is the, now famous, double-stranded helix of the DNA molecule, which contains in encoded form (by means of the "genetic code", spoken of in note 6 of chapter I.) the complete information needed to build up the whole organism (a process called 'ontogenesis'), starting from the fertilized egg (the '*zygote*') in the mother's womb. Of course, it contains, moreover, the complete information for maintaining all its vital functions (respiration, metabolism, etc.).

The chromosome contains, besides DNA, several proteins (in particular: histones). Its structure is intricate; its workings amazing. How 'nature' packs these elongated, compound structures (46 of them!) into the minuscule cell nucleus (its volume may be as small as a millionth of a microliter [6]), always maintaining, throughout, an orderly position that allows several well-controlled rearrangements to be performed all around the 'cell cycle', is a kind of mystery. Thus, in a certain phase of that cycle, a meticulous multiple coiling of each chromosome thread is observed, followed by phases of various kinds of de-coiling.

The transitions between the (multiply) coiled and (partly) uncoiled states mark the several phases of the cell cycle, during its various activities. Of all these, we shall consider only those two most prominent ones: Cell division and protein production. These two processes are at the very foundation of life. Without them, no single one of the millions of forms of life on earth is possible.

There can hardly be a better exemplification of innate 'good ideas' than those implemented in cell life, full of marvel as they are.

Cell division is of two kinds: '**Mitosis**' creates two new somatic cells, 'daughter cells', each identical to the 'mother cell', and 'Meiosis' which produces germ cells, the 'gametes'.

An important step in both kinds of cell division is the self-replication of the chromosomes. From a state where each chromosome contains a single (yet, double-stranded) DNA molecule (in this state, it is called a 'chromatid'), replication sets in at a given moment, producing an identical replica (a *'sister chromatid'*). The sister chromatids remain connected together at a certain point, (a constriction, on each of them), called '*centromere'* (in general, near the middle of their lengths). This gives the chromosome its familiar X-like look (in the coiled-up state).

Let us note: Nowhere is this utterly complicated synthesis of sister chromatids performed in a 'primeval' (or any) ocean, with its unlimited material resources (as in Crick's 'frozen accident'!). It is done within the confines of a tiny living cell; regularly and repeatedly done, without suffering shortage of the required, well-defined chemical supply.

Furthermore: in the course of both mitosis and meiosis we find the formation of a curious mechanical apparatus, called the '***spindle***'. It builds-up at a specific stage in the cell cycle originating at two opposite points (' **poles**') near the surface of the nuclear membrane, (that now starts disintegrating). From the poles, protrusions ('spindle arms') begin to extend in all directions. These protrusions are **microtubules** (tiny tubes; **MT**s, for short), that grow in length by way of meticulous assembly of alternating dimers of the protein ***tubulin*** [7]. The far extremity of the spindle-arms will eventually connect to the chromosomes at peculiarly built, triple-layered, tiny geometrical structures, called **kinetochores**, protruding from the centromeres. [8]

How does the spindle accomplish the task of tracking down, and connecting to, all the individual kinetochores in the cell? The process is most remarkable. At a definite stage, soon after the start of cell division, a strange thing happens: The spindle arms 'move rapidly about', back and forth (these 'movements' are, in truth, extensions, by polymerization, and contraction, by de-polymerization). When the free end (the '*cap*') of a microtubule hits on a kinetochore, it fixates there (there are always those specialized 'workers' (enzymes) present to do that job!).

Curiously, all other activities in the mitotic cell are at abeyance until this 'catching' of kinetochores by the MTs is 'played' to completion; that is: until every chromosome is seized by two (often more) MTs, one (at least) stemming from each pole. The chances of getting this state by the 'blind groping' of the MTs are, understandably, very small. Yet, it must be done, and it is achieved 100% (Flyvbjerg 1997, p.218). Zero tolerance for exceptions! Nature does something surprising: It happens that the MT 'misses' hitting the kinetochore with its cap, just brushing by it from the side. We know what we would do in a similar case, e.g., when, in the dark, we touch a pot, we want to take up, on the side. Our fingers would 'feel their way' along the pot's wall until they hit the handle. Well, the MTs do just that! Instead of contracting and elongating anew, they remain in touch, and grope their way to the centromere.

When this is finished, a new 'play' begins: the chromosomes are "violently pushed, pulled, squeezed", forth and back, by the MT's attached to their two kinetochores, until they settle down ("congress") in the mid-plane (kind of 'equator') between the poles (l.c., p.217). (These movements, again, result from extension of the MT's of the one side, and **simultaneous** shortening of those on the other side, attached to a chromosome.) Having been brought into 'congression', the sister-chromatids of all the chromosomes are now torn apart, by **simultaneous** shortening of all the attached MT's; the spindle halves, collapsing towards their respective poles, draw one of the **chromatids of every chromosome** to one pole, and the other one to the other pole. The separation of all the pairs happens "**simultaneously, as if on command**" (l.c., p.217; my emphasis).

The cell is now ready to complete its division, by execution of a suitable deformation (***'cytokinesis'*** [9]). The described actions, supplemented by many others (unmentioned here), result in two 'daughter cells' identical to the 'mother cell'. It is worth noting, that the 'daughters' are diploid cells, containing 46 (in humans) single chromatids. These, at a later stage, will regain their double (i.e., sister-chromatidic) structure by replication (as said).

How does the cell 'know', that the time has come to divide; that polymerization-depolymerization of tubulin now has to accelerate to unusual speed; that the aim is to 'catch' all kinetochores present within its confines, and to suspend all other activities until the moment this goal is reached? How does it know, that it is, in fact, reached? How do the MTs know the technique of successful groping? These, and other questions remain without answer.

"Mitosis is a very-complicated process" (l.c., p.213). (By the way: not more complicated than the process of *meiosis*, to be subsequently described). We want only to mention one more remarkable factum, attested for the mitosis in yeast: The precision in this performance of the spindle arms, "carried out blind-folded, so to say, like a blind person's probing fingers", is 99.999% (l.c.).

Mitosis is most prominent in embryogenesis. It begins with a single, microscopic cell (a fertilized ovum), and ends with delivery of a baby. Yet, mitosis is with us for the rest of our life, creating new cells to replace apoptotic ones (due to being eliminated). Our organism is a self-repairing machine, exchanging by itself worn-out parts. And it does this "without errors during the **billions of cell divisions** that occur in the life span of an organism" (Lodish 2000, p. 823).

Finally, we come to the promised meiosis: Let us begin with a general characterization by quoting from experts in the matter: As expected from such a delicate physiological process, at the level of the genome: “Meiosis has always been and still remains a mystery” (Verma 1990; p.l0l). Yet, we know a good portion of it: “Meiosis is a complex, integrated sequence characterized by a spatially well-ordered and temporally well regulated succession of events” (John & Lewis, 1973, p.16). Its completion takes up to 24 days (vs. a few hours for mitosis; (l.c., p.4). The exact form in which meiosis unfolds may differ from one species to another; however the basic step is the same: Dissociation of a germ cell (initially containing a diploid genome, i.e. a paternal set of chromosomes, and a maternal, almost identical set; see [5]) into two cells, each containing a ‘haploid’ genome. Meiosis, then, is a ‘reduction division’ (greek: meiosis = reduction): a diploid genome is reduced to a haploid one (in two slightly different copies). In the interest of brevity, we shall concentrate on human meiosis.

The end-product of meiosis is the formation of a gamete: of a spermatid in the male, of an oocyte in the female. The spermatid will develop into a spermatozoon (see [2]); from the oocyte, an ovum (a mature egg-cell) will result. A full description of meiosis (of the known part of it; many features still being veiled in mystery) would fill the pages of a book. Only a few features, those that testify most clearly to ingenious design, will be sketched. The means by which this special type of cell division is carried through are most remarkable; the events are even more dramatic than those of mitosis. Here, the spindle brings the two members of every homologous pair close together, and into juxtaposition of their four arms. This state is called ’***synapsis***’, i.e.: ‘pairing’.

In the first phase of meiosis (the ‘prophase’), the chromosomes are brought together in such a way, that the homologues align themselves along their entire (contracted) length, at a close, but discernible distance. The alignment is effected in such a meticulous manner that, at certain places, corresponding genes in **non-sister chromatids** (i.e. one paternal, one maternal) come to lie adjacent to each other (we remember that the genes follow one another, pearls-on-string-like, along the chromatids). This completes the synapsis.

Often (probably more often than not), synapsis is followed by single or multiple **'crossing-over'** of (one or more) pairs of chromosome arms. Such crossover, also called a '***chiasma***' (pl.'chiasmata', from the Greek letter 'chi', similar to our X), leads in many cases to the all-important process of ***'recombination'***, i.e., an exchange of genetic material between the crossed arms.

These are enigmatic processes. Their unfailing execution requires no less delicacy than 'excision repair'.

What is the nature of a Chiasma? "The molecular nature of a chiasma is unknown" (Levin, 1994, p.978). Yet we have strong reasons to believe that it marks the seat of a vitally important function (to be explained below).

How do the chromosomes recognize their homologues?

"By some unknown means", is the answer (l.c.). How do they find their way to each other, in the dense and crowded nuclear sap (some species have over a hundred chromosomes!); and how do they 'know' to orient and to align themselves so precisely? P.B. Moens states: "It has never been very clear, what it is that brings together the homologous chromosomes at meiotic prophase" (Moens, 1994; Summary [at top of paper]). Levin confirms this statement: " ... the synapsis of eukaryotic chromosomes remains the most difficult stage to explain at the molecular level". (l.c., p.970).

The answers commonly proposed are mainly conjectural. Often they are given in conjunction with tentative explanations about the mysterious construction called the ***'synaptonemal complex'*** (SC). This SC gradually builds up in the small space between the pairing homologues. Its beginnings can be discerned already at an early stage of synapsis; at the end of synapsis the SC is shed-off. However, the workings of the SC itself are full of riddle.

Thus, Maguire (l.c.) has recently raised the question whether the SC might not be a disjunction machine rather than a pairing one.

This whole process of meiosis looks as if the 'twins' (i.e., the homologous chromosomes) wanted to embrace each other, to exchange gifts of their own 'flesh and blood' (recombination), and to say "good-bye" to each other, prior to their definitive separation. For, soon, that 'damned machine' (the spindle) will inexorably tear the loving sisters apart, separating them forever and leading them to their destiny of becoming two haploid cells, i.e. gametes.

Putting aside this emotional outburst: What is it about this spectacular ‘meeting’ of the homologues??

A **most important** circumstance in the ‘forcible’ separation ending their ‘meeting’ is, that the chromosomes are **not** taken apart from each other, by the spindle, in their original composition of haploid genomes, such that the paternal and the maternal genomes be separated. Rather, the spindle-part originating in one of the poles chooses out, **at random**, one chromosome of each homologous pair, dragging them into the vicinity of its ‘pole’ (while the spindle arms are ‘collapsing’; see [7]). The other part of the spindle takes the remaining 23 chromosomes to the other pole. The result of this ‘random choice’ is that, gathered now near the two poles are two haploid genomes, each composed of a mixture of paternal and maternal chromosomes. These will subsequently be formed into gametes.

The number of different possible mixed genomes is enormous (exactly 2^{23}; i.e., nearly 10 millions). This results in a large amount of possible variation between the countless gametes produced by a single mature organism. Since both partners of a married pair dispose of this large range of variation, the range of possible variation in their offspring is of astronomical scale (equal to the square of the above figure; namely: roughly one hundred thousand billions). This genetic variation, as we already know from chapter I., is very desirable, considering that a varied population is the sought-for goal in evolution.

But: What is the purpose of that ‘romantic’ behavior of the homologues, actually of encoded strings of billions of base-pairs?

The real purpose of the process of synapsis with its recombinations is a much discussed issue. That it brings about variations in each of the haploid sets of chromosomes, is undisputed. This strongly suggests, that its purpose is to increase the range of potential variation even beyond the above-mentioned figure. The 19th century German biologist August Weismann, (famous for his having been the first to recognize the importance of the *‘germ line’*, as distinct from the line of somatic cells) has in fact considered this as the main reason for the prevalence of recombinations.

But is it the only one? Some authors are of opinion, that the Weismann’s thesis mentioned above is insufficient to justify the existence (resp.

persistence) of recombination.

From the ‘shortsighted’ point of view of Darwinism, Weismann’s thesis poses a snag: Random Recombinations are quite often disadvantageous, even deleterious (if not lethal). Natural selection might be expected to “select against recombination” (i.e., to eliminate it in the evolutionary process). Therefore, “it is not obvious why” it exists. It “poses a problem”. (Ridley 1993, pp. 199, 203). Evolutionists had to make special assumptions in order that the process could be justified as being selectively advantageous.

Synapsis, with the ensuing formation of chiasmata and recombination, is peculiar to sexual reproduction. It asks for an explanation **transcending** the one required for the question: “why sex”, as raised above. Yet, most interestingly, there is a strong connection between the two, as the following citation testifies: “The problem of why recombination exists is closely related to the question of why sex exists; .. the main point is that recombination is a puzzle. ... and it does not exist simply because natural selection cannot eliminate it.” (Ridley 1996, p.214).

We shall now see how right Ridley is with the “close relation” between the two ‘open problems’. There is a big difference between current Darwinian opinion and ours, in the significance of that relation. For Darwinists, the second problem only deepens the first. As Ridley stresses, the question of why the sexual mode of reproduction persists in evolution and, in particular, why recombination in chromosomes usually occurs during the formation of gametes despite “its dubious selective value” [to the present interests of a species, well understood!], “is still open” (Ridley 1993, p.203). “…one of the major problems of evolutionary biology - why recombination exists” (Ridley 1996, p.212).

Our approach to the whole issue finds solutions to both problems in the same principle: **Variations between individuals** (between humans, primarily), **is a primary goal in evolution**. The course of evolution **is towards that goal**. To this goal we can adjoin another, no less important one: the longevity of the species in general.

Let us first remark that, in recombination, there is not a question of randomly occurring entanglement of DNA threads (as one would be inclined to think, speaking of closely packed threads). Synapsis (the pairing of homologues) is an exquisitely well controlled process; it strictly brings together homologous chromosomes only. (How the cell 'knows' to pair just these, is a riddle of its own). Concerning the crossover sites, it has been argued that "potential crossover sites must in some sense be preselected before becoming entrapped in the synaptonemal complex. How such pre-selection is achieved, if it indeed occurs, is unknown." (John 1990, p.l87). This indicates, that crossover is 'engineered' by the cell in some sophisticated way, for the purpose of recombination. The latter "is under strict genetic control and requires several special enzymes for its operation." (Spetner 1996, p.185). Control is exerted by *a 'recombination activating gene'* (Steele et.al' 1998, p.174)

We have called recombination an "all-important process". We shall now justify this by showing that the second of the two goals mentioned above (species, longevity), is also (in all appearance) ascertained by a process initiated by recombination. Here, Michod's "repair hypothesis" comes in. It postulates that during synapsis the above-mentioned, sophisticated process of damage repair in the double-stranded DNA helix (even when both strands are damaged) takes place, whenever needed (Michod 1989). This hypothesis finds substantiation in the recent discovery that several routine processes of damage repair in DNA **do in fact exist**.

As far as we can understand, we have here the implementation of a magnificent 'good idea' of Nature. The special advantage afforded by this type of repair is as follows:

The incessant sizzle of matter (thermal motion, radiation impact, combined with chemical forces) unavoidably brings with it occasional damage in one or the other chromosome. If this happens within a somatic cell, only that particular individual will be affected. But if it occurs in the germ line , the defect may perpetuate (genes are immortal! see [3]). This is what happens, in fact, in asexually reproducing species. Accumulation of such defects leads, in the course of time, to a species' extinction. (Note, however, that this is no 'reason', for evolution to 'refrain' from reverting to asexuality. Darwinian evolution, is 'shortsighted'! What counts for Darwinian evolution is **present** fitness.)

The fossil record indicates, as a rule, that any species, once established, persists for long periods of time. Perpetuation of a species' life over long periods, then, requires application of an efficient method of damage repair within the germ line. To this end, a 'healthy' gene is needed to be 'copied' onto the 'sick' chromosome, after excision of the damaged part. This is the '*nucleotide excision repair'*, spoken of, above. But, from where to take that healthy gene, when the defect has already spread throughout the germ supply of an organism? Here comes in the 'good idea': Be it even, that another organism of the same species is no less 'afflicted' with damaged genes; the odds for the damaged sites to be the same, in the same genes (the human genome, e.g., contains some thirty thousand genes!), are practically nil. So, let the corresponding chromosomes, of two individuals, pair (synapsis), and the defective genes can, almost without exception, be repaired by excision of the damaged part and copying from the intact part of the other… This is, what "love [sex] has got to do with it" (Michod 1989; see also the 'Further Readings' list, at end of chapter).

The above discourse represents the essence of Michod's thesis (contra Weismann). This kind of damage repair, Michod deems of such vital importance, that it justifies the maintenance of bisexuality.

However, whether damage repair, or amplification of variation in the gametes, is the more important function in synapsis with its recombinations, is **immaterial! Both are of vital importance**; and both are implemented!

This is more than a good idea: it is a *Masterstroke of Nature*! The longevity of species is secured; and (as already said in note 2 of chapter I.): the handiwork of the Creator should not be like the output of a mint!

We have sketched only a very partial list, of the well-controlled, goal-directed, and temporally well-ordered activities occurring regularly in the cell cycles of mitosis and/or meiosis.

Maguire calls the SC a 'machine'. It is. But this machine forms part of a large factory which, itself, is nothing else than one single huge machine, namely the cell-nucleus. Huge in the sense, that within its confines mechanical, electrical and chemical means are engaged in various activities including, as said, breakage of both single-and double-stranded DNA ('nicking'), annealing of strands, insertion (into the broken DNA-chain) of 'prefabricated' stretches of DNA, and others. All these activities have necessarily to be carried out in an "extremely well concerted" way. It is in this sense, that we call the whole nucleus a 'huge machine'. Like in the latter, the various operations are rigorously related in space and time. Some of the activities have to be performed synchronously, others at pre-determined time intervals. This whole 'concert' is directed by a multitude of specific enzymes, each one of them appearing on the stage at the right place and time. These enzymes, very clever and serviceable workers, are always present, at the right moment, at the place where they are needed; and they disappear as soon as their presence does more harm than good. The logistics are perfect; Who is the planner?

Things, no less amazing, can be told about the Proteins. This is a group of organic molecules of almost infinite variety. The human body alone comprises about a hundred thousand different kinds of them.

Molecules of the subgroup of 'structural proteins' are the 'building stones' of which all existing organisms are built. Another subgroup are the 'functional proteins', mostly catalysts (enzymes); They bring about the development organism ('ontogenesis') and control all its internal activities. "Somehow, these small molecules [proteins, and others] implement genetic instructions to build and maintain a structure [a cell] thousands to millions times larger than themselves" (Howard-Gittes 1997; p.155).

Proteins are chains of amino-acid 'residues' (building block-like molecules, each with a distinctive 'flag', joined together by a special chemical bond, the so-called 'peptide bond'). Proteins are the products of genes, carried by the chromosomes. Most genes are 'functional genes', coding for the production of proteins (whence the ancient rule: "one gene, one protein").

A functional gene contains the information of how to form a certain specific protein, by prescribing a definite sequence of amino-acids to be assembled in correct order. No more than twenty different kinds of amino-acids (out of about eighty known amino-acids) are used in the synthesis of all the proteins found in organisms. It is the specific order in which the amino-acids follow each-other in the chain that makes the protein's peculiarity.

Protein production is a sophisticated activity of the somatic cell. Comprising many stages, it resembles the production-line of a chemical plant. The main stages of the process are **‘transcription**’ and **‘translation’** of the information encoded in the genes.

Transcription means the ‘fabrication’ (synthesis) of a molecule that carries a copy of the information encoded in a gene. This is a molecule of RNA (**r**ibo**n**ucleic **a**cid), chemically akin to DNA (as its name indicates). It is formed in a process analogous to that of DNA replication. The strands of the DNA stretch containing the gene are (temporarily) separated, and one of them serves as a template on which the RNA is formed.

When synthesis is completed, the RNA is about the length taken by the transcribed gene on the DNA (i.e.: it is a relatively short ‘ribbon’). The copy of the gene carried by the RNA will, in turn, serve as a template in the protein production process. After undergoing some ‘preparation’, mostly excision of un-needed chain, the (appropriately named:) ‘messenger-RNA’ (mRNA) molecule will transport the information it holds to what could be called a miniature ‘protein manufacturing machine’: a **’ribosome**’.

Ribosomes are one of the several kinds of organelles lined up along a vast web of membrane channels within the cytoplasm. To this end, the messenger RNA passes from the nucleus via specific pores in the nuclear membrane, led by ‘chaperone’ proteins, into the cytoplasm, and ‘seeks’ a ribosome, one that is free to take the job. It attaches to a special site on the ribosome’s surface, a groove called the *‘binding site’* of the ribosome. The ribosome, going into action, **translates** the coded information brought-in by the mRNA into its embodiment, a protein molecule of the kind coded for.

The way this is done is most instructive. **Step by step**, (beginning from a ‘start’-codon, whose detection is the ribosome’s first task), the ribosome **moves the mRNA molecule along**, from ‘code-word’ to ‘code-word’. It ‘reads’ (as it were) every successive word incoming into its ‘reading head’ (i.e., said ‘binding site’), and ‘draws’ from a pool of ‘beads’ in its surroundings, one of them that matches the code. These ‘beads’ are molecules of amino-acid (a.-a., for short), each attached to a small molecule of another kind of RNA, called ‘transfer-RNA’ (*tRNA*). Like the mRNA, the tRNA is also synthesized in the nucleus, ‘emigrating’ subsequently into the cytoplasm. Infiltrated there, the tRNA will soon have an a.-a. molecule of the right kind (a pool of them is always present in the cytoplasma [11]) attached to one of its two specialized 'sites'. This one is called the *'attachment site'*. The other site (called *'binding site'*) bears the 'anticodon' (i.e. the codon complement [10]) of the codon on the mRNA now in the head. This 'bead' is 'drawn' to the ribosome, and the tRNA fits properly with its anticodon onto the corresponding codon on the mRNA, at the ribosome's binding site.

Now comes the surprising step: Assembly-line-like, the ribosome shifts one step along the mRNA-'ribbon', bringing the following codon of the mRNA 'template' into its binding site; while the 'bead', will find itself in another groove of the ribosome, the '*assembly site*'. As soon as the binding site catches a second 'bead' matching the code now in it, the two neighboring amino-acids are bonded together by a special chemical bond, the so-called 'peptide bond' [12]. The first tRNA, now bereft of amino-acid, is dismissed into the plasma, free to 'fish' for another amino-acid of the right kind. This whole process repeats itself until the synthesis of the protein molecule (now also called a 'peptide chain') is complete.

In this fashion the protein molecule, a chain composed of from (about) 50 to several hundreds (rarely up to thousands) of amino-acids, is formed in precise accordance with the instruction originally encoded, and modified post-translation, in the gene.

One should appreciate the astuteness of this 'patent', of using the tRNA as a temporary connecting link. A direct codon-anticodon fitting between the a.-a.s and the mRNA template would obviously have been impossible, due to the bulk of the a.-a. molecule compared with the length of the codon on the RNA. The tRNA is dismissed after having delivered its 'load' to the correct codon site. Only one connecting link is present at any time, giving the growing peptide chain freedom to dissociate itself from the mRNA ribbon.

(The reader who will find all this rather complicated should not feel frustrated by my confession that the above is just a very simplified description; hardly more than a bare outline. The actual process is much more complicated and sophisticated. Calling it 'the workings of a chemical factory' is a stupendous understatement.)

We have stressed the precisely observed timing relations. What about the processing speed (in technical terms: rates of reaction)? The rates of chemical reactions have been extensively determined. One can safely say that the subject is thoroughly known. Yet behold! We have it testified by an expert in the matter, that the rates of the biochemical reactions in the domain spoken-of (at least), are surprisingly high. Treating of protein production, Pritchard declares: “The creation of enormously complex networks of interlinked chemical processes, operating harmoniously at speeds **very much higher** than would be expected on simple chemical grounds, is **perhaps the greatest of the accomplishments of living systems.”** (Pritchard 1986, p.153; my emphasis. We would prefer to say: accomplishments **in** living systems.)

What are the proteins good for?

Besides being good to eat, proteins “are involved in **virtually every biological process**”; yet, “relatively little is understood about the detailed mechanisms by which these biopolymers, ... , carry out their remarkable functions.” (Mendel, p.435; my emphasis).

Ubiquitous as they are, the proteins are overwhelmingly amazing chemical compounds. Our body is composed (ignoring water) of about 50% of proteins. Each of the about one hundred thousand different kinds of them contained in the human body has a specific function to fulfill.

Imagine a long, long straight chain, whose links are those amino-acids we have already come to know. This chain, within seconds after its formation, spontaneously folds into a lumpy body. Yet, its folding pattern (called:’*conformation*’) is exactly defined. Any deviation from the exact conformation would impair, or modify, its function in the organism. George D. Rose, a structural biologist at John Hopkins, says: “It folds unerringly into its proper form. No blueprint guides it. … . But all amino-acid backbones [side-chains] are the same; with so many identical rivals to choose from [in the pairing, at folding], why should the distant residues always pair up **in exactly the same way?** ... Just how a protein assembles itself into its native conformation is a mystery”. “The protein folding problem .. .**is arguably the simplest, yet deepest unsolved problem in biology**.” (Rose 1996, p. 27; my emphasis). And Rose sums up: “Ultimately, the divine fire that illuminates our lives is mediated by the chemistry of our proteins.” (p.31).

Proteins serve not only as structural elements. They are those that play important roles in vital functions of the organism.

An interesting example thereof is presented by the immuno-globulins. This is a super-family of proteins, comprising the well-known 'antibodies'. They are produced by the immune system of our organism. This system has the faculty to produce, **'to order'**! the specific antibody, capable of destroying a given foreign molecule ('antigen'). And the body produces "in quantity" and through a series of "**several extraordinary events**", antibodies of the right and "**unique** structure to match the shape and [electrical] charge distribution of **practically every large molecule in existence**". This capability is necessary to combat the "diverse parasites and disease organisms which would otherwise **rapidly** kill the host" [the invaded body] (Pritchard 1986, p.231).

What could more vividly demonstrate the dependence of our very existence on **'good ideas**' concealed in living stuff?

We should not leave the little fruit-fly (Drosophila) out of the present topic. It has been made the subject of an immense amount of genetic research. Its genome has been completely unraveled, long before the human one. Its ontogeny is intensively studied all over the world; yet, many features of its development defy all efforts of understanding. P.A. Lawrence has shown this strikingly (Lawrence 1993): The movements of cells just formed, from the place of their emergence in the epithelium (surface-lining tissue) to that of their final destination; their 'switching-over' to another function, when the organism is in need of reacting to some contingency ("no cells, or very few, are indispensable", because of this capacity); and their 'knowledge of how exactly' to perform the unusual task of 'switching over' ("yet the wing ends up exactly the right size and shape") , although built to completion by cells alien to that task (l.c., p. 136); all this and much more., - - "there is **a good deal of cell biology and mystery** there" (l.c., p.192; my emphasis).

Perhaps the most wonderful design work discloses itself in the ontogenesis of the fly's eye. It is a "compound eye", characteristic of insects, so termed because it is composed of a large number of identical (but independently generated!) conical elements, called ommatida. A minuscule lens, at the outer end of each 'cone', reproduces on its light-sensitive element (photoreceptor), situated at the other end of each, the image of a small spot in the field of view. The fruit-fly's eye is built of some 750 ommatida, each of which is made of about 20 cells (4 of them forming the lens, and 8 of them the photoreceptor). The ommatida are packed-together very precisely, and no less precisely is the "wiring" of the photoreceptors to the lamina (the flat end plate, at the inner side, from where the optic nerve extends to the visual cortex in the brain), done. Thus, photoreceptor cells of adjacent ommatida, in groups of six that look at one-and-the-same point in the field of view, are connected in such precise way that a **united image is produced**. It has been verified that of 650 nerve-fibers (in the blowfly) emanating from ommatida "none went to the wrong cells in the lamina"; ... "a precision reminiscent of a Swiss Telephone Exchange" (l.c., p.181).

Needless to say, the degree of sophistication in the organization of the human eye is so much higher, and the connection between the optic nerve's fibers and the brain's neurons is "absolutely perfect" (Grassé 1977, p.105). And we say nothing about the brain itself, this highest culmination of connection between body and spirit! The point was to show that ingenious design and its accurate implementation is **already found in primitive animals** of very ancient fossil record. Drosophila is traceable back, on the geological time scale, to the Tertiary (about 10 Myrs ago), perhaps even up to the Jurassic, (some hundred million years ago). However, it is easily outdone by the dragon fly (Odonata), the ommatida of whose eyes are counted in the tens of thousands, and whose fossilized ancestry reaches back to the Permian (some 250 million years ago; all of these data are based on the time scale adopted in geology and paleontology). Another example, drawn from a quite different animal class, are the trilobites (fossil crayfish). They had "crystal-optical, highly developed facet-eyes" with "up to 15,000 adjacent separate lenses" (Krumbiegel-Walther 1977).

These are, then, a few of the remarkable examples, out of, no doubt, an almost infinite number of cases of "**innate intelligence**"**, strikingly implemented in the living world**, both in animal behavior and in physiological processes.

The crucial question imposes itself: What is the source of this 'innate intelligence'? The contention that all this came into being on the basis of fortuitous mutations must, in my humble mind, appear to an unprejudiced rational person as totally preposterous. Yet, serious scientists subscribe to it. Why do they? That is another important question.

In the last chapter, we have brought evidence for intelligent evolution manifesting itself in animals possessing, at least to some measure, "free" intelligence. In particular, we spoke of the tenets of Lamarck, and others, who envisage the possibility of anchorage, in the long run, of intelligently acquired favorable traits in the genome. This is a possible source for part of the embodied innate intelligence.

For plants, and for animals that are not endowed with free intelligence, the problem is different from the start. Whereas in the presence of free intelligence, the problem was to show perpetuation of acquired (i.e., initially non-inheritable) traits, here, where only "innate" intelligence is present, perpetuation by inheritance is insured from the start The problem, here, is to explain how the "good ideas" got into the genes, and how they are maintained when **not** called upon to perform.

There exists an endless plethora of genetic information of the subtlest kind, mainly in the inner workings of the living cells that cannot be traced back to acquired traits. **Here, we are left with the question that is at the heart of our subject: how did the "good ideas",** (or, as we should now better call them: **the marvels of nature,) get into the genes** in the first place?

The choice of examples presented here certainly does no justice to the immensity of marvel and mystery, we have been able, already, to unveil in living cells and organisms; not to speak of the still concealed part. How all this came about, is the issue where the cleft between us, tele-ologists and tele-onomists, is deepest.

We conclude this chapter with a reflection connected with its content:

The unit that initiates the production of proteins, the chromosome, itself contains proteins . The site of protein assembly, the ribosome, also contains proteins. The various processes involved in protein synthesis require the action of numerous catalytic agents, called enzymes; these too are proteins. Ergo: in order to produce proteins, certain special proteins are needed beforehand. How did they appear on the scene? [13]

We see, that Crick's famous "frozen accident" (see chapter 1), must have been (should it ever have happened!) a colossal accident (or, alternatively: a sequence of accidents). In truth, we have already disposed of it. But even concerning Kauffman's thesis: "Life began whole and integrated", we can now realize how demanding this thesis is. Thousands of atoms, or small molecules, of various species had to be brought together, and "integrated" in most sophisticated ways, in order to create life! [14] How in the world is such a tremendous 'magnum opus' even thinkable - otherwise than designed an d guided by a Superior Spirit?

Let us proceed to the next chapter.

Notes to chapter VI

Note 1a. The cycle of sexual reproduction, producing a new generation, begins already in the embryonic state of the parent generation. At this early stage, a group of **pluripotent** cells, (so-called 'stem cells', that are capable of differentiating into various specialized cells), develop (i.e. 'specialize') into primordial germ cells. These migrate from their birthplace in the epiblast (e.g., in the early gut), along a preordained route in the embryonic body built-up so far, to the genital ridges; they 'colonize' these ridges, and multiply by the usual process of cell division ('mitosis'). This whole process forms the 'germ-line', so termed by the famous biologist August Weismann, (important contributor to the modern theory of heredity), who first recognized the strict segregation of this line from the normal line of cell division, the 'somatic line'. Eventually, some of these germ cells undergo 'meiosis', to produce gametes.

Note lb. According to Darwinian thinking, asexual species came into being before sexually reproducing ones. This is conform (at least) to Maguire's "reasonable" assumption that diploidy came into being by fusion of two haploid cells (Maguire 1995, p. 330).

In the haploid cells, at the time, the information needed for their kind of reproduction was likewise stored in their genomes. It may well be, that this information had remained conserved, latent (i.e. inoperative), in the genomes of later evolved bisexual creatures. Consequently, it is quite natural that the 'junk' of non-active genetic material (in man, it makes out about 90% of the total genome!) should still contain these latent genes. The mutation required for a return to asexuality would have been simply one of reactivation of latent genes; a well-known process occurring routinely in higher organisms.

This 'simple' mutation "simply" did not occur.

Note 2. It is worth mentioning some of the remarkable features of this latter process. The spermatozoon has traits characteristic of a primitive single-celled organism. Its minuscule head carries the complete (haploid) genome of the adult who produced it. By means of its swiftly moving tail ('flagellum') it carries that cargo over a relatively great distance in a short time. Like all organisms, the spermatozoon has an urge: to deliver (after copulation) the cargo of genetic stuff in its head to an ovum (a fully developed egg cell). The latter contains another haploid genome. Evidently, 'Nature' has implanted this drive in the spermatozoon, in order that the two haploids might unite to a full complement, destined to become the diploid genome of the developing embryo. A **'good idea'**!

To enable its intrusion into the ovum, the spermatozoon is moreover equipped with the means to pierce the shell of the ovum. Now, imagine the fate of the poor ovum faced with a horde of 'rutted' spermatozoa assailing it? Here again, Nature had a **really good idea**: Following the intrusion of the first spermatozoon the outer surface of the ovum's shell suddenly encrusts with electric charges in order to deter any 'rival' from approaching. Clever, isn't it?

Note 3. So much so, that the daring evolutionist Richard Dawkins was led to advance his "fantasy" of "the selfish gene" pretending that the organisms are nothing more than "survival machines" produced for achieving **immortality of their masters, the genes**! (Dawkins 1989).

For the peace of mind of the reader: "Mendelian inheritance, …, is designed to prevent 'selfish genes' from acts of subversion". (Ridley 2001, p.ix).

Note 4. Nowadays, one speaks of 'Epigenetics' as of a separate branch in Cell Biology (vs. 'Genetics'); a relatively new branch. "Cell biologists are just now probing epigenetic mechanisms". (Science **293**(5532), 2001, p.1063). Among other things, scientists learn more and more details about the (often presumed, now confirmed) fact that quite often a gene does not come to its expression (in the phenotype) by itself alone. Two, or several, genes form a 'team', working together in bringing the trait, anchored in the genome, to its expression.

This explains (at least partly) the great surprise the scientific world had lately (in the wake of the 'Human Genome Project', now "completed"). The elucidation of the human 'genetic map' revealed the existence of **only** about 30,000 genes, falsifying the up-to-then accepted view that the human genome should contain 100,000 to 150,000 genes. Clearly, the immensely enlarged range of phenotypic characters achievable by teams of genes, in various numbers and combinations, dispenses with the need for as many genes as previously presumed.

When this research avenue approaches its full exploration, it will yield just another prominent facet of life's deep-rooted sophistication.

Note 5. This restriction (of being only "nearly" identical) is made, because of a very important feature of genes that we have swept under the rug, so far, in order not to complicate the exposition. Genes generally exist in two (sometimes more) types. Different types of the same gene are called 'alleles'. One allelic type is designed as 'dominant', the other one as 'recessive'. Which type, or types, of allele (s) possessed by an organism determines its ***'genotype***'. In the fertilized ovum (as in any somatic cell), any gene can be of one type in the paternal homologue, and of the other type in the maternal. A dominant gene need not be present in both, in order to be expressed in the organism (i.e. in the phenotype); a recessive gene must be present in both for being expressed; (if so, it is often disadvantageous, if not deleterious).

This feature was a decisive factor in Gregor Mendel's famous discovery of the laws of inheritance.

Note 6. One microliter is the volume of a little cube, of one millimeter side-length.

The figure of **one millionth of that**, for the volume of a cell-nucleus, is obtained as an estimate, from a (worst case) body volume of one meter-cube, of 10^{14} cells per body, and a nucleus/cell volume ratio of 0.1.

Note 7. The microtubule (MT, for short) is a remarkable item in it's own right. The molecules of tubulin, of which the MTs are built, exist in two geometrically slightly different forms. They associate in pairs, one of each kind. The pair is a stable unit, called a 'dimer' (let us imagine it as a two-color brick). The MT is made of such bricks. It is a relatively long, narrow tube (outer diameter: 25 millionths of a millimeter, inner diameter:

14). MTs are 'constructed', very accurately, at a special '**m**icro**t**ubule-**o**rganizing **c**enter' (MTOC), present in every cell. The MT 'grows' from an initial 'seed', as if an invisible hand would put brick upon brick, spiralling up with regularly alternating colors. The extension occurs with surprising rapidity; yet, even more rapid is their disassembly, almost a collapse. So rapid, that it is spoken-of as a "catastrophe". But don't worry! The 'catastrophe' is fully controlled by "MT-associated proteins", (as is also the MT's growth). This 'catastrophic' disassembly is reversible; and, if required by the cell, the reassembly will be done, generally in a new pattern. The patterns encountered in various body parts may be quite complex. Thus, the '*axonme*' (an MT structure that accounts for the mechanical strength to the simple, familiar cilia and flagella) is "an incredibly complex structure" (Howard-Gittes 1997, p.163).

Microtubules are ubiquitous elements, found in most kinds of cells. The length of the 'arms', they form, undergoes changes either by assembly/disassembly or by parallel sliding (one over the other), according to their respective uses. Their usual functions are suspension (scaffold-like) and transport. If scaffold, there should be workers on it. There they are! So-called 'motor proteins', such as molecules of *kynesin* and *dynein*, are busily moving along them up and down, transporting their 'cargoes' (various organelles) to their respective destinations. Motor molecules would be another excellent object for demonstrating nature's marvels. "The problem of understanding motor function [of said molecules] is far from solved" (l.c., p.168).

Sometimes the reason for the presence of microtubules at certain places is in contention. This is the case, notably, for the MTs found within nerve fibers ('axons'). It is known that here, too, they serve for transport along the (sometimes meter-long!) axons. However, their presence in the brain's neurons leads the famous Roger Penrose (whom we already encountered) to the supposition, that these super-precision-built tubes might be the suitable receptacle, for quantum processes to take place within their hollows. Quantum processes could well mediate those sublime mental activities (alluded to in Note 1 of the foregoing chapter) that are believed by Penrose to enable the human brain to perform its finest achievements.

Note 8. The centromere is an enigmatic structure. In general, it is situated at (or roughly about) the center of the chromosome. Through the microscope, it appears as a constriction in each single chromatid . After duplication, and when in its most compact state, the chromosome appears in the optical microscope (roughly) in the form of an X. The centromere, well visible then, sits at the crossing point of the X, which is the point of connection of the sister-chromatids. Only recently have its secrets been partly revealed.

Note 9. Cyto-kinesis is different in animals and plants. In the former, a constriction forms at about the 'equator' of the cell (think of it as globe-like, its 2 poles being those of the spindle), which ends in 'pinch-off '.

In the latter, a separating wall forms, in place of the constriction.

Note 10. Remembering the 4 letters of the genetic code: { A, C, G, T (resp.U) }, the double helix of DNA always pairs C with G and A with T (resp. with U). The anticodon of a given codon is formed by the pairing partners; (e.g., the anticodon of ACT is TGA).

Note 11. Essential amino-acids are not synthesized by the mammalian cell, and must be supplied in the food.

Note 12. This process, of enchaining the amino-acids together by a peptide bond and expulsing the tRNA, is "complex and still not properly understood". (Pritchard 1986, p.158).

Note 13. This gives rise to the familiar "chicken-and-egg" problem, which came first? The question has been debated; solutions have been proposed. But no-one knows for sure.

Note 14. A virus is built out of multiple protein molecules. But no virus has an independent life. Its parasitic existence depends on the existence of a much larger, living host, whose molecular machinery it abuses for its own multiplication. This gives an idea of what was involved in life's integration á-la Kauffman.

Chapter VII.: The World of Spirit

The question posed at the end of chapter V applies also to the foregoing chapter. It was: 'Why should the knowledge about the 'facts of life' (a scanty fraction of which we have seen there) be so important to us?

I happen to think it is very important, because it shows us clearly that the "Spirit of G-d" that "hovered over the Waters" of the Beginning [1] is still, and eternally, hovering over His creatures[2]. It comes to light in all the marvels of nature, through all the "good ideas" and super-refined designs implemented in living things. Last but not least, in human intelligence and creative power.

In our first chapter we endeavored to reject materialistic Darwinism (including neo-Darwinism) without making any reference to spirit. Spetner, in particular, who conducted a rigorous refutation of neo-Darwinism, remained agnostic (presumably, he did so intentionally, in order not to leave purely scientific grounds). Unable to satisfy ourselves with this approach, we prepared in the intervening chapters the groundwork that enables us to reach a more comprehensive view of life (as far as we are able to do this, of course).

Such a comprehensive view should include those of the scientific realizations which an unprejudiced mind recognizes as correct without reasonable doubt. It should also include, we contend, that nonmaterial realm we call spirit. Of the latter, we ourselves are a 'living testimony'.

To the first kind belongs natural history. That is: we acknowledge the fact that there can be no more a reasonable doubt that evolution has taken place, albeit not necessarily in any one of the forms contemporarily espoused. None of these takes account (at least, not explicitly) of the spiritual foundations evolution is rooted in.

Since the dawn of human history, man has followed his drive of wanting to understand. It may well be said, that three themes stood at the focus of his yearning for knowledge: 1. the world around him, 2. his own existence, and 3. the meaningfulness of his life (of his conscious life!). Probably, this occurred in the order enumerated here. That is: in the earlier stages of his evolution, his interests were concentrated on the 'world' around him ('world' meaning for him: his environment). As culture developed, attention turned also to knowing and shaping one's own life, that of one's kin and folk, and finally that of some form of society. At last, the question of 'meaning' arose: "What is the meaning of my life?" By asking himself this question, man transcended animal life. Adam was born.

Adam's birth cannot have been a usual evolutionary step (we have tried to convince ourselves thereof in chapter IV). If, until this event, evolution was guided by the hovering Spirit in a way one may call 'natural', Adam experienced a revelation of the Spirit. In an "act of creation", he was given a human brain; a brain of the sort enabling him to acquire his share in a world that transcends the physical one: in the "World of Spirit".

Science (including its beliefs; see chapter III.) has proved impotent in the quest for answers to 'last questions'. (This is openly admitted by science; we shall elaborate on it further in chapter IX) [3]. We shall now attempt to enlarge our scope, and to see the evolution of the biosphere in the light of that Spirit, that we have recognized as 'hovering' over it. Not that any 'last question' will be thereby answered (who will be so audacious to even envisage that?). The aim is to advance one step further in our understanding of life.

It is a remarkable fact, that early Darwinism did not see itself in conflict with beliefs transcending physicality. A.R. Wallace, the bold veteran of the theory of evolution, mentioned already in chapter I, failed to become the recognized father of the theory of evolution only because Darwin had been pressed to speed-up his publication in order not to be forestalled by him. To the question of the origin of the spiritual nature of man, Wallace answers: "..and for this origin we can only find a cause in the **unseen universe of spirit**." (This citation is taken from the wonderful book by Sir John Eccles & D. N. Robinson: "The Wonder of being Human" (Eccles-Robinson 1984, p.19; my emphasis). Wallace "repeatedly insisted that a purely materialistic explanation of biological evolution failed to account for the spiritual nature of man, ..." (l.c.) That same man, A.R. Wallace, expresses in a letter to a certain Professor Poulton (May, 28, 1912) his conviction of "the **necessity of an ever-present Mind** as the primal cause both of all physical and biological evolution." (Marchant 1916, p.344; my emphasis). Let's listen up: For the top-evolutionist A.R. Wallace, ***an ever-present Mind*** is the necessary cause of evolution !

"The spiritual nature of man". No doubt, man is endowed with a spiritual nature of very special kind. But the reign of spirit, possibly, may well extend much farther than man's imagination can ever dare to delimit. Appendix II presents an outlook upon our present knowledge about the possible existence of life on other celestial bodies (on 'extrasolar planets', also called 'exo-planets').

For the sake of staying on absolutely firm grounds, let us restrict ourselves for the moment to the sphere of life on earth. Here on earth, spirit discloses itself in intelligence. Intelligence is not only an attribute of man! If intelligence pervades all of life (as Grassé professes, and as we have tried to demonstrate, at some length, in the foregoing chapter), this is a consequence of the fact, that intelligence derives from an 'unseen Universe of Spirit', that pervades all life!

"All life" means: from the very first organisms on. While it is very difficult to discuss such matters with respect to forms of life that have existed in the remote past, we have, fortunately, an authoritative statement for the level of the presently extant, most simple living things: The single-celled organism. A personage no less than the famous (alternatively, notorious) Ernst Häckel (we already cited him, right at the start of chapter III), who attributed to every living being, even single-celled, manifestations of psychic activity. He even spoke of a "spirit of the cell": In his words:

"... dass man eigentlich jeder organischen Zelle ein selbststandiges Seelenleben zuschreiben musse. Diese Auffassung wird endgultig begrundet durch das Studium der Infusorien, Amoben, und anderer einzelliger Organismen". "... dieselben Ausserungen des Seelenlebens, Empfindung und Vorstellung, Willen und Bewegung, wie bei den hoheren, aus vielen Zellen zusammengesetzten Tieren" (Häckel 1878, p. 40).

("... that one should, in truth, ascribe to every living cell an independent soul-life. This conception finds its final confirmation in the study of infusories, amoebas, and other single-celled organisms". "... the same expressions of soul-life, feeling and imagination, will and movement, as in the higher, multicellular animals" (free translation).)

True, Häckel stuck to the convictions of scientists of the pre-relativistic era. It was believed then, that all phenomena (including spiritual ones) can, in the last instance, be reduced to "mechanical", i.e. physico-chemical processes ("Mechanik der Atome"). This, however, does not impede Häckel's authority in purely biological matters. What his above words are saying is, that the "soul-life" of all living beings, including the most primitive ones, is of one and the same nature.

It is only too well known, that the mechanistic world view adopted by Häckel was led to doom by the advent of the modern physics of the last century. The theories of Relativity and Quantum-mechanics profoundly revolutionized scientific thought. Therefore, (with anticipation of the insights we shall present in chapter IX.), we recognize the roots of this "soul-life" of all living beings in that "unseen Universe of spirit".

From the single living cell (appreciated by Häckel as we just saw) emerged all life. The spirit, Wallace speaks of, is present in plants, as it is in animals and humans. The laws of nature that determine plant growth (in such peculiar features as those 'phototropic' flowers whose heads track the sun's daily course, or those growing roots that avoid, in spreading, approaching underground gas pipes) have their source in this world of spirit.

We are reminded of the saying of our Sages:

אמר ר' סימון: אין לך כל עשב ועשב שאין לו מזל ברקיע שמכה אותו ואומר לו: גדל! הה"ד הידעת חוקות שמיים אם תשים משטרו בארץ (איוב ל"ח, ל"ג) (ברא' רבה פ"י, ס"ז)

(Rabbi Simon said: "There is no single herb on earth that is not boosted by its constellation in the heavens, prompting it: "grow!" This is [the meaning of] what is written: "Do you know the laws of heaven, or can you impose its rule upon the earth? (Job 38, 33). (Gen. Rabba 10, 7).

The rules of heaven, Job is told, govern everything on earth. This means, (teaches Rabbi Simon): all of life, from the primitive herb (today we would say: from the microbe), upward. In the language of our sages [4], this signifies that every single living being on earth draws its vital force from 'heaven', i.e. from a non-material realm.

The question might be raised: Can two realms of such different nature as matter and spirit possibly have 'chemistry' between them? In other words: can they interact? That 'mind' has the power to act on matter, nobody will deny. Mind produces will; will produces deeds. But: is mind a spiritual (i.e.: an immaterial) **reality**, such that we can say that the spiritual influences the material, producing the deeds?

Materialists wish to deny this; It is therefore gratifying that we have an analogous case in physics. Here an illustrious scientist has given the answer in the affirmative. Physicists have designed experiments, where a material agent interacts with an immaterial one, in such a way that the immaterial agent exerts an influence on the material one. It is the *'Compton effect'*, well-known to physicists. Based on this natural phenomenon, the great Jewish physicist of our time, Eugene Wigner, argues that the reality of 'mind' should not be doubted, just as the reality of that immaterial agent (namely: light) is not doubted. We shall return to this issue right at the beginning of next chapter, whereupon (in ch. IX.) it will also be shown that, conversely, **physical reality** is no less esoteric a concept than **spiritual reality**.

Such contemplation should induce the respect towards life in our minds. This is all the more important nowadays, when in a Darwinian-oriented human society, largely robbed of its long-cherished values and ideals, people desperately quarry for "meaning in life".

The above-cited statements of Alfred R Wallace express the belief, that there exists a domain, a sphere, the nature of which is "spiritual"; i.e.: it is beyond the physical world recognized by our five senses. While until the recent past beliefs were considered by scientific-minded people as "scientifically meaningless", modern physics (as already stressed in chapter III) had to reserve a place of honor for quite a number of beliefs. Within the frame of almost all advanced theories in the physical sciences, beliefs are commonplace. If not for no other reason, they derive their justification from the fact of having proven to be a necessary pre-requisite for making progress. Therefore it would certainly be unwise to discard, on grounds of being "unscientific", the belief in an "unseen Universe of Spirit" (which, of course, has much more in its arsenal of justification than what is said here). A monotheistic believer, (with reference to all of the foregoing), I would dare to formulate thus: There is **One First Cause** for all of existence; it is the Creator. Of Infinite Intelligence, He is the Source of intelligence in all its modes, including consciousness and self-awareness. **He, the One**

Spirit, is the Source of all spirit.

It has been variously recognized, that “evolution must be driven by something” (e.g., Layzer 1988, p.35). But: driven by what? Tempted explanations start from the (correct) statement that, while for the total universe it is certainly true that its entropy must increase, this does not exclude the possibility that a small sub-system of it evolves in the direction of decreasing entropy, without thereby inverting the total trend of increase. Such could be the case, for instance, for the surface of a cooled-down planet.

There is nothing new in this; and no particular drive to evolve a biosphere is inherent in it. Taken for granted that our (or any) planet once in its history featured conditions leading to an entropy-lowering development, this could have assumed a form much more trivial than producing a biosphere, brimful with life. There is an infinity of other possible forms. Almost certainly, one of these would have evolved, were it not that spiritual guidance that drove it. Thanks to this guidance, evolution gave birth to the extraordinary phenomenon, of the very special kind of order that marks the biosphere. Thanks to it, evolution produced the human genius!

The driving force that provides this guidance emanates from the One Spirit, the Creator of the ‘world of spirit’ and of everything else.

This is the place to consider our personal connection with this world of spirit. That we are able to muse about it is due to that marvelous faculty we are endowed with, called consciousness.

Notes to chapter VII

Note 1 At the time the Torah was given to Israel, concepts such as ‘dynamic vacuum’, ‘Big-Bang’, energy, matter, etc. were not known. Even supposing that an enlightened spirit like Moses could have been acquainted with such matters, it would plainly have been of no use to incorporate into the Torah words that would specifically represent such concepts. We may therefore quietly interpret the “Waters” of the first day of Creation as the **‘primeval matter’**. Primeval matter, as seen by the eyes of scientists speaking of ‘Big Bang’, was as uniform a medium as water is in our eyes.

Note 2. It will be asked: Was, and is, this Spirit also hovering over lifeless matter? Any answer to this question evidently pertains to metaphysics. This book does not, as a rule, treatise of metaphysics. However, when we shall come to speak of contemporary physics (in chapter IX), we shall inevitably be drawn to an encounter with it. Today, reasoning about such metaphysical subjects is, no more, alien to reasoning about physics. In the latter, the threshold to metaphysics has already been trespassed, by force of evidences discovered during the last few decades (see chapters IX. & XI.; notably, the parallelism shown there between Jewish traditional views and those of a contemporary eminent physicist, concerning creation).

Note 3. The notion of ‘last questions’ is a relative one, of course. Every cultural period has its specific ‘last questions’. For instance, the ‘last questions’ of pagan people will fill us derision, today. As we strive to approach answers loftier than what contemporary science can offer us, we must not necessarily resign to accepting, that our goal is unreachable in principle. However, future generations will most probably formulate their ‘last questions’ otherwise than we today do.

Note 4. Our sages spoke the language of their time. The belief that the ‘celestial spheres’ influence human affairs was commonplace in antiquity and in the middle ages, though scornfully dismissed by the great Rambam. Still today, very many people stick to astrology. Modern scientists hardly can adhere to the belief that stellar constellations influence human fate. Nonetheless, adepts of the astrological teachings can point to the intriguing phenomena discovered by physicists during the last few decades (to be spoken of in chapter IX.); notably: that particles, when in a so-called '*entangled state*' (stemming from a common source, or having interacted in certain ways), seem to remain in some mysterious connection with one-another, even after separation. The effect has been experimentally demonstrated for particles separated by distances of several kilometers. An upper limit, for such influence to be active, is not known. Of course, this is not meant to furnish a proof for astrological tenets. Yet, it shows that the idea of a possible *'action at a distance'* is not a far-fetched one.

In any case, the fact that Talmudic and later scholars accepted those views cannot obscure the deep lesson given by Rabbi Simon, namely: That the **root of life is to be sought-for in the nonmaterial realm.** It is a lesson we endorse, starting from the point of view developed in the foregoing chapters.

Chapter VIII. Consciousness

In chapter V. we have assessed the extent of the existence or consciousness in the animal world and of the influence its existence can be expected to have had on the course of evolution.

Here, we shall inquire into the nature of consciousness and its origin. To a materialist, recognizing solely a material world, consciousness must appear as a phenomenon of utmost strangeness. For anyone who shares the views expressed in the foregoing chapter, consciousness derives, naturally, from the "Universe of Spirit". Our five senses do not respond to that 'part' of existence; it is "unseen". This however does not mean that there is no interaction. Eugene P. Wigner, one of the greatest physicists of our time, thinks it "more likely" that living matter (in particular: a **physical** brain) not only influences, but also "is actually influenced" by consciousness. The reality of consciousness should not be doubted, Wigner says, just as the reality of light is not doubted, as it never was. It was not doubted despite the fact that light not only is influenced by matter but also influences it, was not known until discovered by Compton, in 1923, quite a while after the inception of the Quantum era (at about 1900). The effect (scattering of a material particle by a photon) is named after his discoverer: the Compton-effect.

The Compton effect (we mentioned it shortly in the preceding chapter) is a laboratory demonstration of an influence exerted on massive matter by an agent that has no ponderable mass ('rest-mass'): a photon. In a rigorously conducted experiment, Compton demonstrated that when a photon 'collides' with a massive particle (e.g. an electron), both particles deviate from their original tracks, just as two massive bodies would do.

The remarkable point is that, in fact, an almost esoteric entity, an 'apparition' without mass, without 'substance', was unanimously ascribed physical reality by the pre-relativistic scientific community. Compton had the privilege to give it a solid experimental underpinning.

On quite a different level, we are in possession of an ‘instrument’ devoid of mass, an immaterial agent, highly capable of influencing matter. This instrument is located in our brain: It is the intellect, based on consciousness. In this case also, Wigner states, should we acknowledge a reality, albeit its true nature is still a mystery to us.

Indisputably, we humans possess a certain, even a quite considerable, amount of knowledge. Anyone will convince himself of that, after a mere superficial inspection of a moderately comprehensive scientific library. This fact alone, rightly appreciated, is exceedingly stunning. This can hardly be expressed more strongly than by the words of the great philosopher of science Karl R. Popper, introducing one of his books. “**The phenomenon of human knowledge is, no doubt, the greatest miracle in our Universe**” (Popper 1972b, Preface; my emphasis).

The acquisition of that huge body of knowledge, and our ability to make use of it, we owe to what we call our intellect. Our actions, too, are driven (mainly) by our intellect (which is not to maintain that all we are doing is very intelligent!). The acquisition of knowledge, as well as a major part of the actions we perform, requires consciousness.

It was exposed in chapter V, that animals possess consciousness. But there is a decisive and fundamental difference between us and them. We, humans, not only know what we are doing, not only are we conscious of our acts; we are also conscious of ourselves. The rock, eons old, does not know that it exists. The earth does not know; we, born out of her womb, do know! We know that we live, that we think, and that we act. And: we know - - that we know! This is what is called “Self-consciousness” (or: Self-awareness).

Self-consciousness is an exclusively human attribute.

Attempts to demonstrate it (even in rudimentary form) in animals have failed. “...it [the animal] **cannot know that it knows**” (Teilhard de Chardin; cited by Ayala-Valentine 1979, p.398); my emphasis). We can! [1]

An utterly enigmatic question arises: How could it have happened that a conglomeration of atoms, be its structure complicated as may, ordered as may, one day gained ‘suddenly’ the faculty of being ‘aware of existence’? And, (at a higher level of consciousness): being aware of **its** (the conglomeration’s) **own existence**? Of being able to say to ‘oneself: “I am”! ?

Science has, by now, no generally accepted explanation for consciousness. It is only fair to admit that (what may be so argued) the fact that no explanation is at hand does not warrant that such will never be found in the future. *Yet, I am strongly convinced that in the case of consciousness, a purely physical explanation can never be found*. The point is, that we are lacking an essential element of the nature of consciousness. On this point, we can agree with the proponent of a vanguard theory about consciousness (we will speak of in a moment, with some measure of skepticism). This theory is (to my knowledge) the most recent of the efforts made by scientists to approach the problem of consciousness. That particular effort, too, is born out of a feeling, that in the tentative explanations advanced so far “an essential piece of knowledge is missing” (Loewenstein 2000, p.309).

It can be said, that the efforts made during the last half-century (including that just mentioned), have in common the prevailing general feeling that the explanation must be sought in the fields of Quantum Mechanics; in other words, in the realm of the atoms of which our brains are made of, or, perhaps even deeper, in the elementary particles composing them.

(The next chapter will take a short look at the strange physical laws that govern the behavior of these ultra-small chunks of matter. Here, we shall anticipate only what is necessary for probing some of the most recent proposals in the field of research on conciousness).

Yet, this ‘general feeling’, too, is questionable. Wigner, whose position about the relation between consciousness and physical law we just mentioned, believes that Quantum Theory is inadequate to explain the phenomenon of consciousness. This emerges clearly from more than one of his collected papers, where he deals with this subject. Thus, he states explicitly: "It is more likely that the present laws and concepts of quantum mechanics will have to undergo modifications before they can be applied to the problems of life." (Wigner 1967, p.202). This is to be confronted with the overwhelming experimental confirmation of the correctness of Quantum Theory, which defies exception as far as experimental techniques have reached up to the present. The dilemma seemed plain at the time Wigner wrote this statement.

Since then surprising new phenomena in the quantic realm have been discovered. The attempt of scientists to use these for understanding consciousness cannot be faulted; Wigner's statements therefore ask for new vindication.

On the other hand, computer science has advanced with giant steps. So, let's see whether (and if so, what) the advances in these two fields (Quantum theory and computer science), singly or combined, have contributed toward a deeper insight into the nature of consciousness.

First, let us hear the opinion of the simplicists, I mean thereby the '***strong AI***' people. (AI is a current short for 'Artificial Intelligence'). The supporters of the 'strong AI' thesis see the brain (in particular also: the human brain) as nothing else than a very complicated, sophisticated digital computer. They consent that, in many ways, our present supercomputers, big and sophisticated as may be, are still a long way behind our brains. But should we once succeed to reach the required level of complexity, they contend, our computers would automatically gain the faculty of consciousness. Should we believe that?

Let me remark the following: It can safely be assumed that, in fact, future computers will be largely superior to the human mind in the solution of many, and various, arithmetic - and logic problems (of course, never without having been programmed properly for yielding a solution).[2]

What the computer will **not be able** to do, (in an essential way unable to do!) is: **to wonder,** and to pose for 'himself' spontaneous questions (i.e.: questions not connected with 'his' preprogrammed work); in particular, questions of a philosophical flavor. Thus, for instance, I would like to ask 'strong AI' people, whether their 'conscious' computer will once ask 'himself' (or a fellow computer 'he' is talking with): Please tell me: How did I come into being? Did I evolve from earthly dead substance, in a long long stretch of time (how long, actually?), by chanceful stochastic events? Or, perhaps, was I designed and constructed, purposely, by a being of intelligence superior to mine?"

I permit myself to doubt that this will ever happen; unless, of course, the computer will have been pre-programmed, by just that superior mind, to ask questions of that kind!

(Should it turn out, contrary to all expectation, that it **will** happen, this would be a matchless demonstration that the Bible's qualification of man's high nature (of being created in 'His own Image') has reached its climax. *'Created in the Creator's own Image'* certainly wants to say: endowed with spirit and creative power.)

The "shortcoming" of man, of not being able to construct a computer endowed with a human mind, is however hardly apt to diminish the greatness of the human spirit. When engineers construct a spaceship, enabling man to put his foot on another celestial body, this is undoubtedly a superb feat; yet, it still is a creation of "something from **something**" . But when Isaac Newton conceived and expressed mathematically the universal law of gravitation, which governs the movements of celestial bodies just as that of an apple falling from its tree; when Johannes Kepler ennounced the exact laws of gravitational motion; and then, scientists and engineers worked out the plans for that spaceship to enable it (and, as the case may be, its travellers) to be launched into outer space, we are perhaps allowed to design this, in a sense, as creation of "something from **nothing**". The body of knowledge did not exist in our world. It was created by the human spirit. Man created knowledge, the use of which enables him to escape the bounds of earth, bounds to which every earthly object is submitted. He did it, defying the universal natural law of gravitational attraction (without violating it!) Not to mention the immense impact Newton's laws had on all fields of modern technology. (Of course, this is only one outstanding example, out of very many). The words "in His Image", I believe, are being made fully manifest.

Nobel-laureate Sir Francis Crick (whom we met at the start), in his book "The Astonishing Hypothesis" (Crick 1994), tries to tackle the problem of consciousness. He admits the flimsiness of his arguments, but adheres to them nevertheless. And here, out to secure his own ends, the atheist is ready to provide an unexpected support for creationism. "Other hypotheses about man's nature, especially those based on religious beliefs, are based on evidence that is even more flimsy, but this is not in itself a decisive argument against them (p.257). In truth, rather than advancing a concrete explanation of consciousness, Crick exhorts scientists to undertake a serious exploratory effort towards elucidation of the phenomenon. He concedes however: "It is certainly possible that there may be aspects of consciousness, such as qualia (e.g. the redness of red, the painfulness of pain), that science will not be able to explain" (p.258).

Roger Penrose, the eminent scientist whom we already encountered in connection with the riddle of entropy, has devoted a voluminous book to the problem of consciousness, marshalling to this end almost all of the modern physical and computational sciences (Penrose 1991).

We have spoken of the ubiquitous microtubules, found in the cytoplasma of most kinds of living cells (chapter VI.; see also note 7, there). Their remarkably precise construction suggests to Penrose the idea that, besides their various well-understood organismic functions, their presence in the axons of the brain's nerve cells ('neurons') might serve a function connected with conscious thinking. In fact, the precision in the outlines of their hollow insides, and the relatively high isolation from the outside they afford, make these hollows an almost ideal space for quantum processes to take place. Isolation of quantically interacting particles from surrounding matter is of prime importance, since otherwise the peculiar quantum state (called *'coherence'*, in the technical language) in which those particles can be (and are supposed by Penrose to be), would be destroyed by the thermal (or other) influence of such matter. '*Decoherence*' of the peculiar quantum-state would result from such influence.

By the way, the endeavor to minimise decoherence is the reason why experiments aimed at producing, investigating, (etc.), a coherent state of matter are normally conducted at very low temperatures (near absolute zero). Clearly, for living tissue (at about 37°C, = 310 degrees abs.), decoherence poses a severe problem. The microtubules, Penrose believes, might offer suitable confines for quantum processes to proceed even at body temperature.

Quantum processes, then, are supposed to be at the base of consciousness. Yet, proceeding further, Penrose is interested in finding an answer to another question: What are the means, our brains use for performing their finest achievements? For producing the great ideas? For finding the genial solutions?

Penrose is persuaded that achievements of that kind **cannot** be due solely to an algorithmically working mind. (An 'algorithm' is a prescribed systematic procedure of calculation; the fashion a computer works.) There must be 'something more' (in chapter V., and note 1 there, we have mentioned this 'something more'). We must be in possession, in our brains, of a subtle faculty of innate mental perception, a kind of intuition. Penrose substantiates this argument with the help of reminiscences of great scientists, and of himself, (no doubt a great scientist, too). When, at occasions, these people grappled with a difficult problem, not being able to solve it despite intensive painstaking, it happened that the arduously sought-for solution 'sprang into their mind', quite unexpectedly, at a time when they were not at all thinking about it. This might be called a 'brainwave'. Penrose believes that its basis is of a very deep nature. In scientific parlance: our brains do not work (not only, at least), computer-like, (i.e., by means of algorithms.) There must be, for such accomplishments (and possibly also for less lofty brain work), "**a nonalgorithmic ingredient**" in our brains (l.c., p.538; my emphasis) [3a,b].

If so, ‘strong AI’ is unrealistic.

The microtubules, Penrose holds, might be the right receptacle for that ‘non-algorithmic’ ingredient.

Even accepted as true, it is not yet an explanation for the origin of consciousness. In fact, Penrose remains with the question: “ -- and how on earth natural selection has been clever enough to evolve **that most remarkable of qualities**”? (l.c., p. 536; my emphasis).

Loewenstein (we encountered him in chapters II & IV.) goes even farther. Like Penrose, he thinks that quantic, coherent processes must be involved in the workings of our minds. But the microtubules he deems inapt to be the carriers of consciousness, seeing they are always located, and always act, inside a cell (‘*intracellular*’). For achieving consciousness, Loewenstein believes, an ‘intercellular’ mechanism (i.e., one that establishes communication between cells) is required. He makes a specific proposal leading in this direction: The ‘*cytoplasmic ground substance*’ of an organismic cell (called also:’*cytosol* ‘) contains a fine network. It is made of microfilaments; they are of even smaller thickness than the microtubules. Its mesh “organizes” an ordered structure of water molecules, by way of forming hydrogen bonds with the mesh’s protein constituents. A proteinic hydrogen atom and a water molecule would act in unison when in a quantum-coherent state. It could function, then, (under the action of an electric field, originating in the natural polarization of protein molecules) in the manner of a switch (a ‘bi-stable’ device). Assuming some further sophistication, it could operate in the manner of a ***‘logic gate***’ (the basic unit of a digital computer). With some measure of fantasy, we can imagine an intricate network of such gates, stretched-out over an immense number of cells (the number of neuronic cells in a human brain is estimated as 10^{11}). This should be physiologically possible, thanks to the interconnections between the meshes of the individual cells, (as known to exist). The gates of this network, by their quantum nature, could function both as the bearers of simple algorithmic computer ‘bits’, and also as ‘qubits’ of ‘quantum computers’, (nowadays at the stage of active development). More than this is expected (tentatively) by Loewenstein: All the millions, or billions, of individual coherent units could unite into one single macroscopic coherent system; "an intercellular quantum coherence" (Loewenstein 2000, p.314). Such a system, incorporated in our brain, could be able to provide us with consciousness; this, at least, is the hope expressed by its proponent.

We can register with satisfaction that Loewenstein is very cautious in his formulations; he stresses the difficulties involved. Thus, concerning our understanding of consciousness, he frankly admits,: "Here, by and large, we are still groping in the dark" (l.c., p.309). His proposal he advances as a hypothesis.

A few critical remarks are in order:

1. Macroscopic quantum-coherent systems have been produced so far only in the laboratory; and this (as said), at very low temperatures only. That such a macroscopic system could be **stably sustained** (or, alternatively, continuously refreshed) in our brains, **at body temperature**, uninterruptedly for many years, is highly questionable. It would require qualities (dielectric strength, and those needed for preventing decoherence) of the brain tissues, in a range that can hardly be expected to exist in the earthly realm. Loewenstein contends: " ... a dielectric protein-water association is stuff with qualities that are found nowhere else in earthly matter." (l.c., p.318). This is most probably true. But still, it 'remains to be shown that these qualities meet in fact the extremely stringent requirements involved, in particular, in the prevention of de-coherence.

2. The systems mentioned above as examples of macroscopic coherence, remarkable as they are, show only such properties as superfluidity and electrical superconductivity. No properties transcending the physical domain familiar to us have been found in them. Is it believable, then, that "the lady with the billion-year-lead" [evolution] knew the "trick", of producing a system that is not only macroscopically quantum-coherent, and moreover stable at room temperature, and, on top of it, also constitutes a powerful non-algorithmic computing device?

3. Finally, the old question (to be addressed to the 'strong AI' people) returns: Let us take for granted that our skulls house such a Quantum-Supercomputer. Its gates, activated by external stimuli register, memorize, trigger responses in the various body-parts, etc., etc.; all this by electrical signals, switching-over the quantum states of logic gates and, running along nerve fibers, and producing actions of all sorts and kinds. Of course, there are many intermediate stages wherein, e.g., the memory is scanned, its information evaluated for the chances of success. Therefrom, and/ or from other factors, decisions about action will result. But, why should we come, on grounds of such brain activity, to say to ourselves (with Descartes): "Je pense, donc je suis" (I think; ergo, I am)? Will a computer, of any kind whatsoever, ever yield an output saying: " 'I' elaborated that fine piece of computation; it proves that 'I' am" ?

It will be remembered that in chapter IV we had a rather lengthy deliberation about the apparent conflict, inherent in Loewenstein's view, between determinism and serendipity in evolution. Clearly, if the course of evolution was completely pre-determined by physical constraints, no 'trick' could have been learnt. If, as Loewenstein contends, serendipity played a significant role in it, is it then reasonable to assume that evolution, equipped only with the Ultra-slow working tools of chanceful stochastic mutations, (assisted by natural selection, and, moreover working under strong physical constraints), produced within an evolutionarily short span of time (see chapter IV.) that tremendous masterpiece, the human brain, endowed with this mysterious faculty of consciousness?

Again, we repeat: The more complex and sophisticated (we find) evolution is, the more the teleological standpoint gains terrain. That "lady" did not play her concerted evolution alone; 'she' had a Maestro Who conducted her concert! [4]

Francis Crick, near the end of his above-mentioned book about consciousness, remarks: "Philosophers are right in trying to discover better ways of looking at the problem and in suggesting fallacies in our present thinking" (p. 256).

The famous Karl Popper, cited above, proposed (in 1993) a "mental force field", acting in what he calls "World 2" (representing consciousness), that would **interact** with "electromagnetic wave - fields" in the physical brain ("World 1 "), representing the unconscious part of our minds. The renowned neuro-physiologist Libet, after discussing Popper's proposal, elaborates on a concept of his own, i.e., on a "**conscious mental field**". This is, no less than Popper's "World 2", an acknowledgment, that consciousness cannot emerge from neuro-physiological processes alone. Libet emphasizes the "intractable mysteries" involved in the interaction between these 'two worlds' (in Popper's terminology), and admits that "**these questions may be metaphysical and ontological in nature**" (Libet 1996, p.223-4; my emphasis).

In summary: Consciousness certainly pertains to an "unseen", non-material realm (akin to Popper's World 2). As the astronomer David Darling puts it: " ... you cannot get ought for nought. Not a Universe from a nothing-verse nor consciousness from a thinking brain. " (Darling 1996).

In face of, and despite the difficulties that scientists encounter in their efforts to explain the nature of consciousness, evolutionists tend to believe that consciousness arose relatively late in the history of organic evolution. Thus, e.g., our by-now well-known, leading evolutionist and brilliant writer, Stephen J. Gould, speaks of "an unsuccessful lineage [that of the great apes] that then happened upon a quirky invention called consciousness" (Gould 1993, p.286). But, to the best of my knowledge, there is ample evidence that consciousness existed in animals very much before that stage. In chapter V., we have seen several examples which (in my humble opinion) convincingly demonstrate that fact. Further evidence seems to be provided by the following considerations.

There is a group of basic problems arising in evolutionary theory, called by Stephen J. Gould "logical frustrations". These frustrations are often expressed by questioning the concept of adaptation and natural selection, in a form such as: "but how could it have arisen in the first place?" (meaning: before the incipient adaptation could conceivably have had a selective advantage). Gould, in a relatively recent book, lends backing to the realisation of several evolutionists, that the solutions to such problems "**often involve an important initiating component of preexisting bias** in sensory and cognitive systems" (Gould 1993, p.374; my emphasis). Three cases illustrating the explanatory power of the assumed preexisting bias are brought there (l.c.); These are worth being mentioned here:

1) The females of the swordtail fish *Xiphophorus helleri* are found to prefer males with a longer 'sword'. This is a kind of 'female choice' (a factor in sexual selection, well-known in several variations, in the animal world). It was however found in a series of experiments, cleverly conducted by Alexandra Basolo, that females of a co-generic species (i.e. another species belonging to the same genus), "a close relative", but whose males lack the sword (X. maculatus), prefer those males, of their own species, into whose tail a 'sword' had been **implanted**! This finding clearly demonstrates, that the bias of 'preferring males with swordtail' existed before these swords had even evolved. As Gould states it: "female preference predates the evolution of the sword in swordtail fish", (since, as said experiment showed, it is present also in the swordless species, which preceded the swordtail). And Gould, frustrated, raises the question: How did it come about, that such an easthetic bias be present, latently, in the swordless species?

2) A male frog's call attracts females of its species. The call is a "specific mate recognition" signal, shared by all members of a given species. The Panamanian Tungara frog emits a peculiar call, composed of a so-called 'whine' of essentially low frequencies ('fundamentals'), and a so-called 'chuck', comprising a substantial amount of higher harmonics. The female's ear, (correspondingly, one would assume) is fitted with two papillae (an exceptional feature for a terrestrial vertebrate, though amphibian); one (called the 'basilar papilla') is of high sensitivity to the whine, the other, to the chuck. Again, another frog species, closely related to the Tungara type yet lacking the male's chuck, was examined. The spectral response of the female's basilar papilla showed essentially the same sensitivity to the high frequencies dominant in the chuck although, in the absence of the chuck in the male's call, it is useless. The basilar papilla, then, is an "everpresent,

but initially unexploited capacity". It "provides the *'preexisting sensory bias'* (Gould, p378); this time, a bias for **responsiveness to a non-evolved chuck**.

3) Another "logical frustration" (for evolutionists) is the widespread reluctance from incest, "in vertebrate species with complex behaviors and high cognitive capacity" (p.379). It is not obvious, from an evolutionary standpoint, how early ancestors could possibly have had a premonition, that mating with close relatives will deleteriously affect the quality of the genetic constitution of a significant fraction of their offspring. What is the immediate cause of that reluctance? Goal-directed experiments, performed by the 'classic' British ethologist Patrick Bateson with birds (Japanese quail), showed that "quail prefer first cousins over true siblings". This remains the case even when the siblings **never saw each other before**. Accordingly, the argument of 'familiarity' as a cause of incest avoidance can be ruled out. (Bateson 1982).

Bateson speculates that quail "may be following a **highly abstract aesthetic rule**" [my emphasis]. Gould suggests, that such "aesthetic preference" might be common to a wide range of animals; with the surprising consequence that "natural selection need not work for the specific [and evolutionarily important!] goal of avoiding incest." "**By good fortune** [Gould believes], a **deeper cognitive principle** engenders this result as a consequence" (1.c., p. 380; my emphasis).

We should sit up and pay attention! For the avoidance of incest, in the long run so important to evolution, "natural selection need not work"; avoidance is insured by a "general cognitive rule" (Such a rule also tells the female fish: 'Prefer swordtails'; or, "Prefer larger [more imposing] males"). Gould finds his proposed "solution" (namely: the existence, in many animal species, of a 'deeper cognitive principle' engendered by 'Lady Luck') "elegant (and probably even true in these cases -- what a rare and lovely combination)" ... "if Lady Luck smiles on the beginning of such an evolutionary trend". With all due respect for his high expertise and brilliance: Gould, to whom all the marvels of nature are the work of 'good fortune', how can **he** speak, here, of a "rare" combination, brought forth by a smiling 'Lady Luck'? Who would maintain that combinations, stunning and 'lovely combinations', are rare in in the living world?

The correct conclusion to be drawn from these examples is that they serve as a clear indication that adaptations, to a much wider extent than commonly believed, are likely to be rooted in a "deeper cognitive principle". To ascribe the origin of the principle to whatever 'fortune', could perhaps be due to another 'preexisting bias'!

The epistemological route gone through in this whole issue seems to me highly remarkable. Gould set out, at the start, to find an answer to frustrating questions about evolutionary theory, of the kind: "how could it arise in the first place"; and he arrived at the general answer of "a deeper cognitive principle". However, this immediately triggers the further question:how does a cognitive principle arise? (which was, 'au fond', exactly our starting question!). These cascading questions are reminiscent of the eastern myth, "explaining" that our globe is prevented from falling "down" by an elephant sustaining it. (This elephant, of course, must in turn be sustained by another one, and so on ad infinitum). Gould has a simple answer to the second question: The deeper cognitive principle arose thanks to "Lady Luck". All these "quirky" beginnings are "fortuitous". Lucky be he who finds this kind of explanation satisfactory! If, for want of more solid knowledge, one is reduced to believe in something, it seems more reasonable to believe that these "aesthetic preferences" are manifestations of animal consciousness. Should we rape our intellect by asserting that the drive to "prefer larger males" is not an outcome of consciousness? The peacock's long and beautiful, but clumsy, feather tail is a paradigm for 'fitness-reducing' features, found, interestingly, especially in males, and believed to have evolved for the purpose of attracting females. Various theories have been advanced to explain the mechanism of their emergence, within the frame of evolution by natural selection. In particular, two competing theories have gained popularity: Fisher's "runaway" theory, and Zahavi's "handicap" theory (see note 7 of chapter V.).

As an alternative, I would suggest that this problem may well find its explanation in a deeper cognitive principle; or, as put by Bateson: in "a highly abstract aesthetic rule followed by the female". Interestingly enough, this would be, in a sense, a return to Charles Darwin's original (and much rejected) conception, that "a great number of male animals ... have been rendered beautiful for beauty's sake", which "may serve as a charm for the female, and for no other purpose" (cited by Cronin 1992, p.286 ff).

We are led, then, to severely restrict the conception of a merely mechanistically working 'natural selection', acknowledging the decisive role played by a **quite general "deeper cognitive principle**".

Rejecting (as we do) any possible role of good luck, we are driven to the question: What is the nature, what the origin of that "deeper cognitive principle"? Seemingly, there are only two choices: Either it is a principle innate, in one form or the other, in every living being, or it is a mode of consciousness, restricted to those animals that are endowed with. Should it be innate, its origin can hardly be sought-for elsewhere than in metaphysics. Most people will probably vote for consciousness as for its origin.

In any case, from all the features in animal life highlighted, it seems established that consciousness is not a "quirky invention" of recent origin; it pervaded the living world long before humans came on the scene. And consciousness certainly pertains to an "unseen Universe of spirit". So, again: we have arrived at the threshold of metaphysics (which we dare not transgress!).

All psychic activities, loves, hates, pains, pleasures (including such refined ones, such as the most sublime aesthetic pleasures) derive from consciousness. In particular, the extremely intense urge of self-preservation exhibited by (at least) the higher animals (including insects, spiders etc.), so well known to anyone of us, testifies, that they are conscious of an immanent threat to their life, or limb. We said: "exhibited by at least the higher animals", because there the feature is so well-known. In truth, the urge of seIf-preservation is innate to every living being. It could even be used as a defining characteristic, distinguishing living from dead matter (Lipson 1988, p.15). The assertion, that consciousness in the animal world is ancient, applies therefore in the fullest sense, down to the very cradle of life.

This contention should be properly appreciated, in the light of the thesis (as expressed by Prof Lipson, Israel Prize in Physics, and a fervent adept of materialistic Darwinism), that "the existence of **living beings that struggle for their existence** is a **necessary condition for the "survival of the fittest**". (l.c., p.16; free translation from Hebrew; my emphasis). We have seen a fine example of such struggle, of an amoeba; in note 6 of chapter V. But although the amoeba is called there (by Grassé) "the simplest of all animals", it is, by far, not the smallest. The much smaller Archaea have survived, while struggling, since the earliest days of life on earth; their remote descendants are thriving, and struggling, still today.

The question imposes itself: Imagine lots of atoms that have been bound together chemically into self-reproducing molecules, (by pure chance); these latter having in the course of immense stretches of time increased their organisation (well understood: merely through stochastic rearrangements of themselves, and formation of chemical bonds with surrounding matter); having moreover had the "good luck" of perpetuating (and therefore being called "most fitted"): can one possibly imagine this clump of 'organized' atoms spontaneously to develop an urge to evade the disintegration of their organized structure? Even more: to evade the mere threat of danger (of disintegration)? It sounds crazy. The only 'voie de salut' is to make a connection, of whatever kind we might choose, between the 'world of matter' and the 'world of spirit'. The contention of the 'strong AI' people, that a brain of sufficient complexity leads automatically to consciousness, is plainly contradicted by these 'low' creatures, that know to evade a threatening danger even without having a brain at all!

Let us return to humans. Self-consciousness leads to the unique and characteristic human quality of 'personality'. It comes to its towering expression in great men/women. All those honorable scientists who advocate for teleonomism surely do not want to have denied their being endowed with personality. Would they agree with the contention that it is pure chimera? However, ponderable matter as such cannot possibly have fundamental qualities leading to this attribute (unless, of course, one would be ready to admit that matter itself is rooted in an “unseen universe of spirit”).

The attempt to explain the purposefulness of all the prodigious adaptations, so profuse in the living world, with help of the concept of teleonomy was already deemed outrageous to many people. To try to explain the emergence of consciousness on these grounds (that is: without reference to a non-material realm), seems, at least, extremely far-fetched, if not impossible.

Stevan Harnad, professor of cognitive science, in a review of several new books treating the subject of consciousness, wonders whether someone could, by a “mirabile dictu” (miraculous utterance) explain this “hard problem”, that “everyone else so far has failed”, and that “may never yield to cognitive science”. With the sentence: “This is one unsolved mystery we may all just have to learn to live with”, he concludes his review (Harnad 2001; p.36). As to self-consciousness, its “emergence and development ... is an utterly mysterious process” (Eccles-Robinson 1984, p.30).

Consciousness is no doubt the most extraordinary of all phenomena in the known world. And it is the one that most forcefully rebuts the doctrines of materialistic evolutionists. This faculty of consciousness is what enables us, humans, to muse, and to speak, about the nature of things and - **about our own nature**; about our being endowed with consciousness and, -- in particular, with self-consciousness.

NOTES to chapter VIII

Note 1: An offshoot of self-awareness is death awareness. The practice of burial of the dead testifies to the presence of such awareness. Ceremonial burial is universally practiced by man since prehistoric times; yet, it is completely absent in the animal world (Ayala-Valentine 1979, p.398).

Note 2. Attention has been drawn to a “dilemma” , inherent in the trend to expand the domain of A.I. further and further. “... , as the amount of knowledge grows, it becomes harder to access ... ; so, more knowledge must be added to help. But now, there is even more knowledge to manage, so more must be added, and so forth” (Rich 1983, p.21). As a consequence thereof: the required amount of memory capacity will ‘explode’. Although this is a purely technical problem, it might well reach a practical limit at a point widely distant from , ‘strong A. I.’ people’s aspirations.

Note 3a. Penrose strongly bases his argument (of the non-algorithmic faculty of the human brain) on a very deep theorem in mathematical logic, enunciated in the thirties of the former century by the Nobel-laureate Kurt Gödel (and named after him: ‘Gödel’s theorem’). This is not the place to delve into the subject in detail. In short: Gödel proved the incapability of any algorithmic system (resp. program), extensive and sophisticated as may, to ascertain the validity (the ‘truth’) of a certain proposition that can be formulated by the system. (This proposition is called the “Gödel-sentence” of that particular system).

Since, in contrast, our intellect enables us to ascertain the correctness of a Gödel sentence, our intellectual faculties, Penrose argues, necessarily transcend those of any computer, including the (potentially known) Quantum computer (Penrose 1989).

This argument has been challenged (see, e.g., Loewenstein 2000, p.315, and his forthcoming book announced there). It is not up to us to take position here. Our standpoint does not depend on this issue, as far as the relevance of Gödel's theorem is concerned. Our belief in the superiority of the human mind is based on the conviction that it derives from the world of spirit.

Superiority of the human mind over any thinkable computing machine is Penrose's conviction, as can be judged from his writings. He has also been quoted stating: "Understanding is a quality, I claim, that cannot be captured in any form of computation whatever" (Anderson 1996, p.27).

David Mermin is one of the brightest minds in contemporary physics, and important contributor to the arduous work (ongoing for almost a century) of elucidating the 'Quantum world' and, more particularly, of illuminating the dark state of confusion created by the wealth of perplexing experimental results in quantum physics during the last few decades. He sees himself forced to take refuge in the unfathomable capacities of the conscious human mind for giving an ultimate answer to those perplexities. "I shall take the extraordinary ability of consciousness [to do what physics cannot do [5]] as a **deep puzzle** about the nature of consciousness." (Mermin 1997; my emphasis). Still, four years later, he mocks the division of contemporary scientists into "those who say consciousness is a non-problem because the question [of understanding the nature of conscious experience, etc.] does not make any sense, and those who say it is a non-problem because the answer is obvious" (Mermin 2001).

Note 3b. In this context, a cute idea of Penrose's is worth being mentioned here. It aims at leading 'ad absurdum' the opinion of people who support both 'strong determinism' ("the state at the present moment completely determines the state at any later moment"); and 'strong AI' ("everything is computable"). To these people, Penrose proposes the following 'Gedankenexperiment' (Penrose 1987, p.118): Sit down before your supercomputer and feed-in 'all about you' (a complete map of your genome, the state of the atoms constituting your brain, etc.). Then, let the computer calculate your future (by strong determinism, this can be done, in principle). After that, do something different from what the computer has predicted you will do; clearly we have reached an absurd. In consequence, contenders of strong determinism have to acknowledge that the human brain produces thoughts, wills, and acts that transcend any deterministic computational predictions; i.e.: for them, at least, the strong-AI thesis is totally unacceptable.

Note 4. The term 'concerted evolution' has its place in the theory, though I did not enter the subject. There is ample evidence for the undoubtable occurence of identical, or very similar, courses of evolution taken in different lineages. It gives rise to much speculation and differing views, among atheistic scientists. The teleologist, of course, will have no reason to be surprised. There is a 'Maestro', Who directs the 'concert'.

Note 5. The words enclosed in these square brackets replace Mermin's which, being specifically theoretical, are perhaps too technical for the general reader. For the interested reader, here they are: " ... to go beyond its own correlations with certain other subsystems to a direct perception of its own underlying correlata". It is a rather bold step, undertaken by Mermin, to rely on the mysteries of human consciousness in order to solve a persistent conundrum in Quantum Mechanics. It is rooted in the thesis (he supports), that **physics is restricted** to deal only with *correlations* between things (*'correlata'*); it cannot deal with the correlata themselves.

These correlata are akin to Kant's "Ding an sich" (the thing proper). Physics, Mermin says, can only deal with the correlations **between** the 'things proper'. To explain the **nature** of these 'things proper', -- physics is incompetent!

In this light, is **'Physics**' as mighty as many believe?

After lecture of the next chapter, the answer of most readers will probably be: No!

CHAPTER IX. Mysterious Universe

In the foregoing chapters we spoke quite a lot about the 'world of spirit'. It was tacitly understood that, in truth, we know nothing about the true nature of that world. On the other hand, we sometimes believe that, when we speak of material objects, we **do** know something about the true nature of what we are speaking of. It will be the aim of the present chapter to convince ourselves of the truth of Mermin's words (just seen in the last note), namely: that this is not the case; we are not much better off here than in the case of spirit. Just as we referred to the "turmoil" around evolution (right at the start), and that new theories come up almost every year, so it will be here. This is the main reason (besides, of course, the interest the matter itself presents) this chapter has its place in our book.

We know that air is fleeting, that water is liquid and volatile (it evaporates); we know that, in contrast, the rock is steady for eons. Is it? You can falsify me by pointing to the erosion weather has produced on it in the course of a few hundreds, or thousands, of years. OK! So let me take, as an example, the diamond. It is a crystal, consisting of a regular arrangement of billions of carbon atoms. Before it was dug out by the diamond-hunter, it was buried under the earth for billions of years, since its formation. Its atoms did not leave their well-determined places in the crystal lattice for a moment. They stuck firmly together, making this crystal the hardest and most durable natural substance known to man.

What will happen, when we take out one single carbon atom of the crystal? (We can do that! When we heat up the diamond to a very high temperature, single atoms will 'evaporate' off the bulk). It has been done; with diamond, as with many other kinds of materials. And strange things have come to light.

Imagine a boy having built from his 'Lego' an impressive construction in the form (more or less) of a diamond crystal. Let him then take off one Lego-stone. What he will have in his hands, is a piece of matter of same nature as his whole construction; a little part of the whole, showing no properties differing from those of the whole. The atom of the diamond, in contrast, has properties that are **enormously different** from those of the bulk crystal.

Thus, for instance, if the trajectory of the atom, (as it flies off the hot crystal surface, bullet-like) will lead through a very small aperture (a tiny hole, or a very narrow slit) in a plate placed in its way, the atom will not fly straight-on through the hole (or slit), as expected. A bullet would do so (provided, the opening is a hundred times wider than its own diameter, and leaving aside the rare cases when it would graze the aperture's edge). The atom, (in proportionally the same conditions as the bullet), will be deflected; i.e., it will deviate from the straight-line trajectory it followed before meeting the aperture. [1]

We have here a completely general rule; it applies to all kinds of submicroscopic particles. Without regard to of what material a macroscopic body is made of, or which of the ninety-two chemical elements its atoms are, invariably the properties of a single atomic (or sub-atomic) particle taken off from it are fundamentally different from those of the bulk. The physics treating of these fundamentally different (and strange, it must be said!) properties has been named 'Quantum Physics' (or Quantum Mechanics, or Quantum Theory. The reason for the first part of these appellations will soon become clear). We shall present justifications for the assertion that **the true nature of matter is veiled from our eyes**, not less (at least, not much less) than the world of spirit is. We can say, unhesitatingly: The **reality** of the material Universe as it presents itself to us at present, a decade into the 21st century, is, well, **'mysterious'**. Mysterious to the point, that certain physicists put 'reality' itself into doubt!

There is one fact, which no single serious scientist of today will deny: Modern science has uncovered the utterly enigmatic nature of the physical world; at least so in the sense, that the physical facts discovered during the last century, and the new groundbreaking scientific principles derived therefrom, **are at odds with our intuitive cognition**. Ironically, this insight has dawned upon the minds of a few genial scientists just at a point when classical physics had reached its climax; when, towards the end of the 19th century scientists proclaimed, that everything about the material world is already known in principle, and only the details would still have to be worked out. It transpired at that epoch that the long-established, intuitively easily graspable concepts and principles of physical science were unable to account for a number of natural, or experimentally observed, facts that came to be known around then. The two most influential, pioneering scientists of that epoch were Max Planck (whose name is associated with the advent of Quantum mechanics) and Albert Einstein (the founder of both the Special and the General Theory of Relativity). They conceived of a number of new and (partly) counter-intuitive physical principles, in place of the classical ones. They succeeded, eventually, to enforce the acceptance of these principles upon a reluctant scientific establishment. The new physics launched thereby and, in the sequel, further developed by them and many other scientists, required a complete re-orientation in scientific thought. On the one hand, Quantum physics recognized the 'quantic' (ie. discrete) nature of what was formerly thought to be continuous, namely: radiant energy (light, radiant heat, radio-waves, etc.). On the other hand, Special Relativity claimed the intrinsic unity of the two concepts always believed to belong to separate categories: space and time.

There were more reasons for feeling vexated. Quantum physics operated with a set of mathematical rules devoid of logical justification. Teachers had to justify the use of such rules by words like: "You cannot understand this; you have to get accustomed to it", (or, somewhat less politely: "Shut up, and start calculating!"). Or: "We have to admit our ignorance; we use these rules simply because they work (i.e., they lead to the correct predictions of experimental results)". The teachings of the theories of Special and General Relativity were, no doubt, even more overthrowing. Yet, both Quantum theory and Relativity theory have firmly established themselves during the course of the twentieth century, despite the many challenges they had to overcome.

Let us list just some of the most important principles of these revolutionary, but now already known as "classical", theories (to distinguish from the more 'modern' ones):

1. Radiant energy comes, particle-like, in discrete and indivisible lumps, called 'quanta'; energy is not a continuous medium, as formerly believed. The quanta of light (as also of radiation of any kind) are called '*photons*', Single photons can be both produced and detected, experimentally. Under proper circumstances, a photon behaves like a particle (e.g.: in the photoelectric effect, a single photon 'knocks out' one single electron from an atom). Yet, it retains also wavelike properties which manifest themselves under other circumstances.

2. All material particles (electrons, protons, neutrons, etc.) disclose, along with their particle-like properties, also wave-like (or, what comes to the same: light-like) properties, given suitable conditions (e.g., in electron microscopy, in neutron diffraction, etc.).

This is the converse of point 1 stated above, which ascribed particle properties to radiation (which usually behaves wavelike, showing diffraction, interference, etc.). This common property of physical entities which always were perceived, and conceived, as being of quite different nature, is called the "***wave/particle duality***". Today, it is unanimously acknowledged as a **universal principle**, in flagrant contradiction with our intuitive distinction between a particle and a wave. Wave/particle duality also entails, as a matter of principle, that it is impossible to determine both the exact position of a particle and the exact momentum it has at that position. The more precisely its position will be determined, the less well-defined its momentum can be at the moment of position measurement. And vice versa. This is a special case of Heisenberg's more general "uncertainty principle", applying to various parameter-pairs whose values physicists would like to be able to measure, a deadly blow to basic classical physics, according to which both these parameter values are, in principle, well-defined at any instant, and should therefore be measurable.

One of the most perplexing properties traceable to the wave-particle duality discloses itself in the following experiment:

A thin sparse stream, made of many identical particles (photons, electrons, small atoms, etc.), passes through an apparatus, **one particle at a time**. To every single particle of the stream, two alternative routes are open for continuing its flight. The alternatives could be (e.g.,) passing through one of two narrow slits made side-by-side in an opaque screen. This is the famous *'Young's double slit experiment'*. Passing through, the particle hits a fluorescent screen (or a dense array of detectors), revealing the point of its impact. Surprisingly; after a time sufficient to accumulate many particles, this intermittent stream traces out, point by point, an interference pattern of maxima and minima, just as a classical, strong pencil of light rays would have done instantly. Since, here, only one particle at a time passes the apparatus, we are forced to conclude that each particle makes its way through both routes (slits) simultaneously, thereby undergoing '*interference with itself*'!

The piquancy of this 'self-interference' lies in the fact that these particles will **not arrive** at certain definite places (the 'minima' of the interference pattern on the screen or the detector-array), where they **do arrive** in a regular way, when only one of the routes is open (the other route having been obstructed). In other words: the fact that a second route is **given free** to the individual particles, **prevents** them from arriving at points where they impinge regularly when that second route is obstructed. This curious '*single particle self-interference*', predicted by Quantum theory, has been experimentally verified not only with the evasive, mass-less photon, but also with the heavy neutron, weighing nearly 2000 electron-masses.

The *single-particle interference pattern* is only one of a series of experimental results indicating, that a thing we normally conceive as a submicroscopic particle **can be in two places** (e.g., slits) **at the same time!**

The illustrious physicist John A Wheeler has driven this dilemma to its extreme. He proposed to examine the light arriving from a distant, luminous astronomical object (e.g., a quasar), having passed-by nearby an intervening galaxy, on its way to earth. According to Einstein's General Theory of Relativity, the galaxy could act on the bypassing light as a '**galactic beam splitter**'. The light reaching the fringe region of the galaxy would follow the space curvature produced by the huge mass of the galaxy, being focused by it (as by a lens) onto earth. The physicist examining the photons incoming on earth could now choose, alternatively, either an experimental setup for assessing their particle nature, or another one showing their wave nature (e.g., producing interference fringes). According to the result, we shall determine them as either particles that, necessarily, have passed at one point, only, of the galaxy's periphery, or as waves refracted from all around it. It will appear as if the "photons must have had a premonition, telling them how to behave, in order to satisfy a choice to be made by unborn beings on a still un-existing planet" (Wheeler 1992,p.75).

These words, no doubt, express the immense perplexity the implications of this duality are apt to evoke in the mind of a great scientist.

In the light of our present experience, there may be a good chance that Wheeler's expectation will be fulfilled, in either case, should scientists succeed one day to perform the twofold experiment. It will be much harder to gain an intuitive understanding of what really gives rise to such vexing phenomena.

3. No material object can be said to be at either absolute rest or in absolute motion. Rest and motion are relative concepts; they depend on the state of the observer trying to decide which is what. In fact, who has never experienced an impression of being oneself at rest, when sitting in a gently moving train, or airplane, and looking outside; or conversely, of being in motion when looking at a moving vehicle while oneself is at rest?

'We' usually undeceive ourselves quickly of such misleading experiences. Einstein recognized the underlying basis of our ephemeral illusions: we refer to the earth below our feet as fixed and resting. Yet, we know that in truth it is not! Einstein's thesis is, that we have, in truth, no reference point of 'absolute rest', whatsoever, in the whole Universe, that would enable us to decide about 'absolute' rest or motion.

[Lately, with the exploration of the '*Cosmic Microwave Background*', which has contributed so much to the corroboration of the cosmogonic hypothesis of the 'Big Bang', there appears, prima facie, to be such a possibility; (i.e.: a body from which the background spectrum would appear isotropic with respect to Doppler shift, might be considered as being at absolute rest). The issue, apparently, is not yet ripe for discussion.]

4. Space and time are **not** separate fundamental entities. Rather, there exists, (according to the Special theory of Relativity), a "***space-time continuum***". Accordingly, the manner in which space and time are experienced (as they in fact are; namely as separate entities), differs for observers in relative motion with respect to each other. Strange consequences, result therefrom, for two such observers. Let us imagine them sitting, e.g., in two spaceships, moving "gently", at high relative speed, in opposite directions. Since motion is relative, each observer may (and naturally will) consider himself (and his observing equipment; i.e.: his "***reference frame***") as being in a state of rest and, consequently, the other one as being in a state of motion. As a result thereof:

a) each one of the two observers will find all the material objects that are at rest in the reference frame of the other observer (including the latter himself) as shortened in the direction of observation, compared with the measured linear extension of identical objects at rest in his own frame. This effect is known as "*Fitzgerald contraction*" (or, also: 'Lorentz contraction', after the discoverer of the mathematical formula expressing it). Concurrent with this strange 'contraction', is another (strange) effect: the clocks stationed in the 'moving' frame appear to the 'stationary' observer as lagging with respect to his own clocks ("*time dilatation*"). This reciprocal, apparent lagging of "the other's clocks" is plainly contradictory. It has given rise to the famous, once arduously disputed "*clock paradox*" The paradox has however found its solution within the context of General Relativity [2].

An ensuing, most interesting (although, most probably, illusory) consequence is, that astronauts travelling in an extremely fast-moving spaceship will come back to earth less aged than corresponding to the travel-time shown by our earth-stationed clocks. The reason thereof is, that their 'biological clock' also was running more slowly (as seen by us; to them, the distance of the journey appeared to be very short!). As an extreme example: upon their return to earth, they will meet their remote descendants! [3]

b) Simultaneity is a relative concept: what appears as simultaneous to one observer, will appear as occurring non-simultaneously to another observer in relative motion with respect to the former. At first sight, this is blatantly counter-intuitive. Yet, an example will make this clear: Imagine that we see two short flashes of light appearing simultaneously at the horizon, one from the top of a tower at the east, the other from a tower on the west. Feeling ourselves at rest, and having ascertained the distances of the towers from us to be equal, we are able to conclude that the flashes lighted up simultaneously. An astronaut, sitting in a satellite passing at that moment over our heads in the eastern direction, will see the eastern tower approaching him, the western one receding. Knowing that it took some time to the flashes for the travel from the towers to his eye, (and that the light's speed is constant; see below), he will deduce from the simultaneous arrival at his eye, and from the different distances of the towers from him (that of the eastern is shorter than that of the western, by 'Fitzgerald contraction'!), that the eastern flash must have been emitted after the western one. (It is however noteworthy that, despite our upset about the shattered intuitive feeling of simultaneity, causality **is** preserved, both here and throughout the modern theories; a cause will always appear as preceding its effect.)

We should not be misled by this simple example into thinking that it will always be in our might to explain the physical world this easily. For Wigner, for example, a macroscopic 'event' is the result of "an interaction of human consciousness with the physical world which cannot be explained within the framework of the laws of physics itself" (Leggett 1987, p. 94). This will be demonstrated in the sequel.

The renowned physicist Paul Davies devotes his book "About time" to the problems, the 'flow of time' raises in physics and cosmology. He concludes: “Rivers (oceans?) of ink have been spilled on the subject, yet still the flow of time is as mysterious as ever.” (Davies 1995, p.253)

We may illustrate the mystery of time by an extreme example: When an astronomer sees through his powerful telescope a very distant luminous object (a galaxy, or a ‘quasar’), he calculates, at hand of his formulae, that the light reaching his eye had travelled through space for millions, or billions, of years. As has been done already by others (in other contexts), we shall now make use of a variant of the famous trick invented by the great Clark Maxwell (his equations for the electromagnetic field are fundamental for the mathematics of this field up to this day). When Maxwell investigated the laws of thermodynamics, he imagined a ‘demon’ sitting near a small hole in a partition-wall between two vessels. The demon would hold the hole closed most of the time, opening it only for allowing a fast molecule of air to pass from the left to the right vessel, or a slow molecule from the right to the left one.

Let us imagine now a ‘Maxwell’s demon’ riding (in the fashion of “Munchhausen on the cannon ball”) on a photon, as it departs from said galaxy or quasar. The demon would ‘experience’ his flight to earth as made in ‘no-time’. In fact, to the demon, the whole world would appear as a disc, of infinite area (perpendicular to his direction of flight) but of vanishing thickness. Likewise, a human astronaut travelling with near-light speed would see the visible firmament shrunk into a disc of finite thickness, crossable within a short time. A striking realization of the mysterious relativity of time.

c) a measurement of the speed of light, performed by any two observers in their respective frames of reference, will always and invariably yield one and the same result, no matter what the relative speed of the (uniform) motion between them is. Both will get the same value of (very nearly) 300,000 km/s, (as measured for the first time by the Danish astronomer Olav Römer. in 1676). Firmly established by Einstein, the speed of light is a *universal constant*. It has therefore been agreed upon to denote this value by the letter c. (This figure, c, is one of a small set of universal constants, known. Its value, therefore, has been determined with utmost precision.)

This fact (of the constancy of the speed of light, no matter in which state of motion the observer, measuring it, finds himself) appears very paradoxical. The **observed** speed of any **material** object is always the **relative** speed between the observer and the observed object. (For instance, to an observer sitting in a swift-flying plane, another plane passing by at slightly higher speed will appear as moving forward very slowly.) One would therefore expect the speed of light, too, to appear more than c to an observer moving swiftly towards the incoming light, and lesser than c to an observer moving swiftly in the same direction as the light.

The absolute constancy of the speed of light, irrespective of the state of motion of the observer, has been firmly established; for the first time, in the famous Michelson-Morley experiment, in the nineth decade of the 19th century (still without grasping the true nature, and importance, of their result). It is utterly intriguing, and had been the main spur for Einstein to develop the Special Theory of Relativity. Follows from it, too, that irrespective of the chosen frame of reference, no material body can ever reach a speed equal to c, although it can, in principle at least, approach it to any degree (see [3])

5. Mass (m) and energy (E) are intrinsically identical; they differ only by the form of appearance. The energy content of any material object is related to its mass by Einstein's famous formula $E=mc^2$ [energy content (E) equals mass (m) times the square of the speed of propagation of light (c)]. Conversely, radiant energy bears with it an amount of mass deducible from this formula. It is only a consequence of this identity that mass may get annihilated, through its transformation into radiant energy. Here, again, Einstein's formula holds sway. (A well known example is the annihilation of an electron-positron pair, yielding radiation in the form of a pair of gamma rays.)

6. According to the central tenet of General Relativity space, (in our primitive conception: an abstract idea devoid of 'substance'), suffers a

certain, well-definable distortion under the influence of any massive object contained in it.

The human mind is incapable of picturing this so-called “space curvature” brought about by the presence of ponderable matter. Mentally, we can grasp it only by supposing that, in addition to the three spatial dimensions accessible to our senses (and to the dimension of time), there exists (at least) one more spatial dimension; which is inaccessible to our senses and into which three-dimensional space is “curved” (just as a two dimensional surface, such as a thin flat sheet, can be curved in three-dimensional space). Mysterious? Awkward? Yes, no doubt. Luckily, any number of supplementary dimensions can at least be made intellectually ‘graspable’ with the help of mathematical means.

It would be erroneous to pretend, that with these two mainstream theories, Relativity and Quantum mechanics, the progress of physical science into unknown territories came to an end. On the contrary, intensive and extensive mathematical studies, on the one hand, and experimental research (with its often surprising results), on the other hand, have brought an immense expansion of knowledge in the field of physics during the last half-century. Yet, two points can be made:

1. The basic tenets of both theories (Quantum Mechanics and Relativity) remain unchallenged by the vast majority of the scientific community, after having proven their predictive power in all cases when they were put to experimental or observational test.

There is however, up to the present, much dispute over the proper interpretation of the principles of Quantum theory, as well as of the puzzling phenomena discovered lately (to be spoken of, below). There are, moreover, tribulations around the question, whether the principles of General Relativity remain valid in the realms of extremely small extensions and extremely high energies.

2. The advances (referred to above) made since those days render our world only more profoundly mysterious. The statements of two first-rank

physicists leave no doubt about that:

"... such hopes [that a deeper theory would be discovered, showing that the world was after all free from oddities] were shattered..."; and: "**the weirdness of the quantum world is real, whether we like it or not.**" (Tegmark-Wheeler 2001; my emphasis).

We need not, in order to exemplify that weirdness, enter into a description of the modern, complicated experiments which prove this. Above, we mentioned the simplest of these examples: the classical 'Young's double slit experiment'. It is still today the most fundamental attestation of this "weirdness". A plethora of more and more sophisticated experiments, performed since, have only enlarged our knowledge about the extent of a weird atomic world.

The root of the complications that have arisen during the last few decades dates back to a long-standing controversy, initiated in the mid-thirties of the last century by Einstein, Podolski and Rosen (EPR), and turning around the correct interpretation of Quantum theory. The critique of this theory, published by these authors in 1935, brought to what has come to be called the '*EPR-paradox*'. Sustained efforts to clarify this issue have produced new insights which, in turn, were corroborated by experimental findings. In their wake, a conviction held since Newton, and until the Einstein era, by virtually all scientists (and unconditionally defended by Einstein until his last days), has been shattered. Namely, the conviction that there cannot exist an instantaneous "action at a distance"; rather, any influence exerted at one place can propagate to another place only at a finite speed, whose maximum is the speed of light (c). This condition is referred to as 'locality' (more definitely: '*Einstein-locality*'; to distinguish it from a weaker kind of locality, which prohibits only signal transmission faster than light). Einstein-locality states that any change occurring at one place is a local change; it cannot exert its influence at another place instantaneously. It takes time; at least the time it would take a pulse of light to get there. [4]

New experiments, pioneered by the French group of A. Aspect et.al., came in 1982. Their planning was guided by certain opposing predictions of classical and quantic theoretical work. Well, then, the mathematics has taught, and experiments have confirmed, that if we do not want to place into doubt the very fact of the '***physical reality***' of the things we conceive as real, ***nonlocality*** must, in all appearance, be accepted as a physicaI reality, too. There seems to be no other alternative. Granted that logic is a sound tool of cognition, ***there is*** instantaneous action at a distance! ''Many experimental facts establish ***non-locality*** as an inescapable 'fact of life' and [or?] cast doubts on the notion of '*elements of reality'* (Venugopalan 1995, p.578). "In summary, **there is no escape from nonlocality**". (Peres 1998, p.173).

In premonition of this dilemma, it was conjectured already much earlier that: "... the concept of 'physical reality' as far as inanimate objects are concerned, may itself lack physical reality". (Jauch, Wigner & Janase, 1967). In similar vein, the influential modern physicist Roland Omnès declares: "... language has no power over reality and can only acceed to it through phenomena" (Omnès 1999, p.182) [5]. This means that we are **absolutely forbidden** to use '*counterfactual reasoning*' (that is: to use logical deductions from known facts for predicting hypothetical results of unperformed experiments). Only what has actually been experienced (that is: only an observed phenomenon) can be taken as reality. The rule: "**Unperformed experiments have no results**" is ever-repeated by Peres. This outstanding Israeli physicist has moreover brought the proof that observance of this rule is of compelling necessity (in order not to run into trouble), not only in attempts to make *predictions* with help counterfactual reasoning, but also for deducing past 'realities' ('retrodiction') by such means (Peres 1994). In chapter XI we shall encounter an even stronger statement concerning the true nature of any natural phenomenon whatsoever, from the mouth of one of the greatest scientists of our time.

In consequence, Einstein's, and common sense's, quest that we should be able to assess logically deduced 'elements of reality' as being **just that** (and not merely constructs of our minds) can apparently be satisfied only at the price of accepting also the reality of the existence of an intrinsic connect between particles, expressing itself in non-local effects. Under proper circumstances, this intrinsic connection (called '*entanglement*' in the professional jargon; see note [4] chapter VII.), gives rise to instantaneous mutual influences. This property persists even after these particles have separated to a considerable mutual distance. Thus, an operation performed on one particle at a given moment influences, (it is believed), the other, distant particle at that very same moment (or at least, with superluminal transmission speed).

Consequent to the violation of the Einsteinian '*principle of local causes*', the principle was replaced by the notion of 'Contextuality'; meaning, that the result of an experiment performed at place A **may**, on circumstances, depend on its 'context', (to which a simultaneous event at a remote location B belongs). Of course, this does not lift the mystery. In all appearance, nonlocality must be accepted as an established fact. A great number of experimental results seem to confirm it irrevocably. But behold! What has become almost a 'concensus' since Aspect et.al's epoch-making experiment, (namely: nonlocality), has nevertheless recently been challenged by first-rank scientists. This is perhaps the most striking demonstration of the lability of the 'state of the art' in physics, even in our days! However, contesting nonlocality comes at a price: for this one must be ready to resort to one or another recently advanced esoteric theories (see[5]).

Another striking property (closely related to the above) of entangled particle-pairs is, that after a measurement is performed on one of them one can, on basis of the result, predict with **certainty** and **precision** the outcome of an identical measurement that will be performed on the other 'particle' (more exactly: the other half of the 'two-particle'). This is in contrast to the otherwise generally valid 'uncertainty principle' ruling the behavior of 'normal' quantic particles ('Heisenberg-uncertainty'). Proposed by the famous Karl Popper, the experiment (named after him) has confirmed this proposed outcome.

I venture the conjecture, that everything that has been unraveled so far about nonlocality (inasfar as it is, in fact, nonlocal; in any case, it is puzzling!) is only the tip of a huge iceberg, still to be brought to light in the future. This can be concluded from the following utterances of two leading physicists: Wilczek (cited above, ch.III) "summarizes" his analysis of the essence of Quantum Mechanics by expressing his feeling "that after 25 years -- and **innumerable successful applications** -- we are still two big steps away from understanding Quantum theory properly" (Wilczek 2000). Mermin, inquiring about the future developments in fundamental theories, poses the question whether in the year 2100 there will "still be serious people, as there are today, who feel that **in some fundamental sense we don't know what we're talking about**? (Mermin 2001; my emphasis).

Let's ponder about the deeper significance of this puzzling, yet (purportedly) empirically well established fact of nonlocality. Primarily, it says that what appears in all other respects to be two particles is, and remains after spatial separation and despite it, one indivisible non-local entity. (It is now called a 'two-particle'). Should this fact not lead us to the idea that all the elementary particles in the world be in truth one single nonlocal entity? Once, in the remote past, they all had a common origin in that most extraordinary space-time singularity called the Big Bang! We should be led to its ultimate implication; namely: to the idea of **the intrinsic unity of all existence**. [6]

The idea of the global intrinsic unity of the cosmos has gained fairly widespread acceptance during the last century. It has been repeatedly expressed by the outstanding quantum physicist David Bohm in his writings (e.g., Bohm 1951, p.161). In televised interviews Bohm reaffirmed it. He pointed out clearly, that the world is a "wholeness", and that viewing it as constituted of separate parts is, in truth, a "fragmentation" of this wholeness effected by the human mind for the purpose of analysis. This 'wholeness' (we may perhaps call it: 'oneness') should, Bohm believes, be describable (in principle, at least), by one single mathematical function: the "wave-function of the Universe".

Other leading physicists have lately expressed similar views. Thus, e.g., H.D. Zeh conceives of the world as governed by a Quantum mechanics based on the "assumption of a global Schrodinger wave function(al)", which should be "interpreted as **representing 'reality'**, and from which all physical processes (including "all classical aspects"; notably: the existence of '*particles*') would be "derivable" (Zeh 1993; my emphasis). Essentially the same idea has already been expressed before by others; namely: that what appears to us as 'particles', are in truth '*vacuum excitations*'. Thus, e.g., in Bohm's conception of Quantum theory, "particles are then actually conserved forms of excitation of the "ether". (Bohm-Hiley 1984, p.272).

A. Peres, who is one of today's leading Quantum theorists, similarly declares : Because "we are compelled to use only incomplete information on the world, ... we work as if the world could be dissected into small independent pieces. This is an illusion. **The entire world is interdependent**." (Peres 1998, p. 172; my emphasis). On purely scientific grounds, then, Peres comes to the conclusion that, to a mind equipped with incomplete knowledge only, the world necessarily presents itself as composed of separate parts. The implication thereof seems to be, that to an Omniscient Being the whole Universe is one indivisible wholeness.

We recall the saying of our sages:
והלא במאמר אחד [היה] יכול להיבראות
("The world could have been created in one single saying". (Aboth, Ch. 5, 1).)

Is this wholeness not suggestive of a connection with the Oneness of the Creator? We should therefore, again, be led to the conclusion that the **One Infinite Intelligence** is the **Ultimate Cause** of all '**coming into existence**', and the **Driving Force of 'evolution'**.

Evolution (as we have come to know it) was launched by a twofold act of creation: First, of a **Universe**, inconceivably hot and, despite this, of utmost low entropy, at the 'Big-Bang' (cf. chapter IV.); then, at a later stage, of **Life**. Of a life that unfolds, in the sphere of earth, (and, for that matter, wherever in the universe life should exist in one form or another), to ever-increasing order, thanks to the **Driving Force** that endowed life "with its several powers" (Darwin).

Let us close our look on the mysteries of our world (including the 'dead' physical world!), by putting on the table some exotic fruits of modern physics -- we would say: of the 'Pardes' (the all-encompassing 'Garden') of science. There is a recent theory, a scant couple of decades old which, startling as it may seem, appears to many scientists to be most promising in its ability to fill the lacunae of all the former theories. Even more important, it is perhaps the first significant step towards satisfying the enduring longing of scientists for a comprehensive theory. Sought for since long, such a theory should unite, in one single scheme, all known forces of nature. It is referred to as a "Grand Unified Theory" (GUT).

The theory alluded to, called "String Theory", is a most amazing product of human creative thought. In it, the spoken-of elementary particles are pictured as being, in truth, tiny vibrating strings. The mode and frequency of the vibrations would determine the identity of the particle.

Fine! But how small is tiny? Well, tiny is an inconceivably short measure, called the 'Planck length' (postulated to be the absolutely ultimate in smallness!); it is of the order of 10^{-35} meters (that is: the hundred thousandth part of a billionth of a billionth of a billionth of a millimeter!). Yes, we are expected to believe that such unbelievably tiny strings are the ultimate constituents of all matter in the cosmos. The reward for it is a much clearer intuitive picture of the strange world of particles.

This is by no means all we have to accommodate our minds to. There is, firstly, the further extension of string theory to '*super-string theory*', which aims at getting a more symmetrical picture of the world of particles. Furthermore, as the Caltech-astrophysicists Morris & Thorne state, " .. there is strong reason to believe" that, according to the theory, at the smallest possible distances (of the order of 10^{-35} m) "quantum-gravity effects dominate", making space-time not an absolutely smooth, continuous medium (as usually conceived by our minds), but rather of a grainy nature (just as, by analogy, any fine photographic picture reveals itself under a magnifying glass as grainy pixels). The interstices between the 'grains' form the so-called 'wormholes'. Space-time is "foamlike"! (Morris-Thorne 1987, p407).

Not only cosmologists; Quantum-physicists also consider seriously the possible existence of worm-holes. It has been suggested, that these micro-wormholes in space-time (or, possibly, in one or more of the supplementary dimensions postulated by '*super-symmetry*' theory) might provide "*backdoor connections*" between distant particles. Thus, particles, either of common origin or having interacted in the past, could remain interconnected via these worm-holes in spacetime, even when they separated by a considerable distance. This would be the explanation for those intriguing non-local effects spoken-of above. (Don Howard, 1997; p.129).

(Who dares to indulge in speculations about possible future insights? What are the implications of such foaminess? What could possibly be there, hidden from our five senses?)

Yet, the summit of cosmos-encompassing human thought is no doubt to be found in modern cosmology. Believe it or not: there is a theoretical possibility (in principle at least, albeit only under very special circumstances), that there can exist (besides those sub-sub-microscopical 'wormholes' pervading all space-time) also discrete 'wormholes' of macroscopic size. Through such a wormhole, a space-traveler could escape from our universe at one place, and re-enter it at another, very distant place. Or, even, could he gain access to another universe, one of very many possible other universes! [7]

This is perhaps the place to stress that these are not the brain-products of science-fiction story-tellers. They are serious ideas of scientists that, equipped with heavy mathematical apparatus, escalate from the solid grounds of the "classical theory of General Relativity." [8]

Contrary to philosophical theories produced throughout historical times, which had no predictive power for testing their validity, at least the main stems of the two main modern theories (i.e. the classical theories of Quantum-mechanics and of General Relativity) have been amply verified (within the limits of our perceptive abilities), by both observation and experiments especially devised to this end. We have been compelled, by force of overwhelming evidence, to accept their counter-intuitive features and the oddity of their mathematics.

Concerning the latter, and concerning their powers of explanation and prediction, it has been said: "... its success remains **the main mystery of science**" (Omnès 1990, p.364; my emphasis)

"...; for [cosmic] dust thou art, and unto dust shalt thou return". Only, that this cosmic dust is endowed with properties far more profound than scientists of today can conceive. Scientists are people that, so-to-say, examine the world through a microscope (for the micro-cosmos), and a telescope (for the macro-cosmos, i.e. the Universe). But the power of such instruments is limited. Although, at present, with the scanning tunneling electron microscope and the space-borne telescope, their optical power having reached undreamed-of heights, one limitation is inherent: the greater the optical power, the more restrained, with respect to the naked eye, is the field of view.

The same, metaphorically, can be said of scientists: the more they specialize in their fields, enriching their ever-growing and deepening knowledge, the narrower necessarily becomes their global view. This is a first limitation, due mainly to the limited speed of assimilation and memorization of new knowledge, of our brains. Another one, I believe, is a fundamental limit, possibly determined by kinds of 'templates' inherent in our brains (like those found in the white-crowned sparrow; chapter V.).

We can realize most clearly our fundamental limitations, when our reflections focus on the unfathomable extremes. On the one side, the vastness of space: After all we can figure out, it is of immeasurable dimensions, perhaps infinite ones. Our telescopes catch photons from cosmic radio sources ('quasars'), that had to travel at the speed of 300,000 km/sec for billions of years before reaching us. Yet (as we have seen), the physicist when speaking of 'Special Relativity' asserts, that photons (these familiar corpuscles we manipulate with ease in our laboratories!), were they endowed with consciousness, would 'experience' this vast distance crossed as vanishingly short. Something ungraspable hides behind this conclusion of Special Relativity.

On the other side, General Relativity, in spite of its spectacular successes in the celestial domain, is jeopardized in the realm of the infinitely small. At the smallest distances dictated by Quantum Theory (the "Planck length") one of the fundamentals of the theory gets seriously put in doubt: the postulate of the continuity of space. As we have seen, scientists come more and more to realize, that at this scale, space is no more a continuous medium; it is 'grainy', or 'foamy'.

As a result of thorough analysis of the latest findings in experimental physics, Don Howard comes to the conclusion that "experience, ... , suggests that Quantum mechanics is right and General Relativity wrong". (Howard 1997, p.129).

It would probably be more correct to say, that both theories miss the ultimate truth. In the foregoing, we have quoted the great physicists Eugene Wigner and Roger Penrose, as doubting the ultimate correctness of present-day Quantum Theory. So, both theories are on trial.

In a similar vein: it is certainly true, that scientist's basic concepts about the ultimate constituents of matter (and this includes radiant energy!) already abounding with mysterious properties (e.g., the 'spin' of elementary particles). Yet it is no less true, that nobody can rightly contend, that those basic concepts about particles exhaust their real nature. Roger Penrose (with whom we are familiar by now) has expressed it thus: "...we are, **at best, a very long way** from any kind of ultimate understanding of the nature of our Universe" (Penrose 1993; p.82; my emphasis).

Eminently pertinent to the problems connected with these two extreme realms, micro-cosmos and macro-cosmos, is, that "there have already been hints in modern physics that the **small and the large are intimately connected** (Minkel 2002). If correct, we would be personally involved with!

We should not be too much surprised by this statement if we recall our discussion, above, regarding the intrinsic unity of the world. Basically, Minkel's statement (while perhaps somewhat daring), is certainly not preposterous. "Intimate connection", as an implication of 'intrinsic unity', sounds logical. The "hints" referred to but, (regrettably), not referenced by Minkel, will surely be found worthy of further consideration.

This closes our short excursion into physics. The human spirit has become aware of the extreme complexity and "strangeness" of the material world, on the one hand; and of the need to admit (and to accommodate mentally!) the existence of fundamental entities not accessible to our intuitive power of imagination, on the other hand. Moreover, just as it was said in connection with evolution, one can say that, to this day, the entire study of physics is in some disarray. There have been recent voices (allegedly) announcing the disproof of the Special Theory of Relativity (Rodrigues-Sharif 2001, p.1772), or the General Theory (Howard 1997, cited above). As for Quantum Theory, the correctness of teachings of renowned theorists, such as Bohm, Omnès, Penrose, and others, has lately been contested (Deutsch-Hayden 2000; Fuchs 2002). And all this (I repeat!), despite the spectacular experimental and observational successes (and, hence, corroborations) of these theories in the recent past.

Our comfort in this embarrassing situation has been properly expressed by d'Espagnat, a leading phiIosopher-physicist: "...although **we cannot know mind-independent reality,** still we get, through Physics**, not fully deceitful** glimpses of it" (d'Espagnat 1999; my emphasis).

The explicit aim of the foregoing list was, of course, to show that those evolutionists mentioned at the begining (the "reductionists") 'jumped from the frying pan into the fire' when trying to explain the unfolding of the living world on the purely materialistic grounds of physico-chemical processes. **Physics itself bears the hallmark of the metaphysical!**

M.A Nielsen & I.L. Chuang open their specialized treatise on the new branches of *Quantum Computation and 'quantum Information'* (important branches, that are now at the stage of intensive study, and on the verge of industrial implementation) with the words: "Science offers the **boldest metaphysics of the age**". It enables us to "grasp the true strangeness of the Universe" (Nielsen & Chuang, 2002; my emphasis).

In the face of such metaphysical strangeness of the material world, shall we dare '**rationalize the World of Spirit**'? And to deduce thereof implications about human moral responsibility?

Notes to Chapter IX

Note 1. It is a fundamental result of Quantum theory that the degree of deviation from its straight course which an atom (or any other micro-particle, for that matter) will suffer as it passes through a sufficiently small aperture, is unpredictable. In principle, it can be at any angle between zero and ninety degrees.

The wave aspect of micro-particles discloses itself in the pattern of the deflection (in technical language: the 'diffraction pattern') obtained, when a large number of observations of such deflected particles is made. It will be exactly equal to the pattern a beam of light of a certain color would produce when directed at the aperture. Diffraction patterns of many sorts have been thoroughly investigated since the nineteenth century. All have found their explanation, mathematically, as wave phenomena.

Note 2. It is a consequence of Einstein's deep insight into the connection between gravity and acceleration, that a clock (more generally: the internal motion of any body) at rest in a gravitational field should go slow with respect to a clock (resp. an identical body with internal motion) not subjected to that field. The observational and experimental confirmation of that prediction was one of Einstein's great successes, leading to the general acceptance of his theory of General Relativity.

The clock paradox arises from the freedom of the astronaut (Relativity accords to him), to consider himself at rest. In doing so, the astronaut will see all the stars moving (in the opposite direction we, on earth, will see him moving). He cannot move all the time at constant speed; his rockets will impart his ship acceleration (positive, when leaving earth, negative at his return trip). Feeling himself at rest, the astronaut concludes that an all-pervading gravitational field is the cause of the 'free fall' of all stars, the counterforce to his rockets keeping himself at rest.

The important point resulting from the General theory is, that the more an astronaut traveling in a spaceship will have gained distance from earth (and thereby increased the apparent time disaccord between his and earth-stationed clocks), the slower the running of his clocks must be (in his view) in the phase when he sees the stars falling towards him (which, for us, is the phase when he accelerates for his return to earth). This slow-down (in the judgement of the astronaut, supposedly physics-literate!) will exceed the lagging of the earth-stationed clocks as apparent to him (by the 'time dilatation' of Special Relativity), and lead to agreement at his return to earth.

Note 3. The 'time dilatation' effect actually occurs in nature. Certain unstable 'elementary particles' ('muons') persist much longer (until their decay), when originating in the upper atmosphere, than those produced in the laboratory. This lengthening of the 'lifetime' of the 'cosmic' muons is attributable to this 'time dilatation' predicted by Einstein for fast-moving objects. (Again, the cosmic muon, being factually the same kind of 'creature' as those on earth, 'experiences' its hi-speed journey to Earth as shortened by a Fitzgerald-contraction of the distance, rather than as thanks to a long 'life'. Should a physicist be at rest in the muon's 'reference frame' and measure its lifetime, he would find it the same as that we measure on the laboratory-produced ones.)

It may be worth keeping in mind, that the underlying circumstance that leads to the mind-boggling effects of Special Relativity, is the physical limitation in our ability to perform the synchronization of distant clocks in a Galilean system (i.e., a system moving at constant velocity). The transfer of information from one clock location to another can be effected, at most at the speed of light. In consequence, when a 'master clock' (say) sends out synchronizing time signals to the other clocks of the system, they will arrive there with various delays. A correction for these delays could easily be made, using the known distances, if the speed of light were already known to be independent of the motion of the system. But for finding out, we need synchronized clocks. It is a vicious circle! If we could transmit synchronizing signals at infinite speed, Physics would be much different from our present one. (But the whole world, too, would be quite different from what it is!) Einstein's 'verdict', that the speed of light is also the maximal speed of signal transmission, is imperative!

Note 4. 'Einstein-locality' (also called: '*the principle of local causes*') is often expressed, equivalently, in the following form: 'The outcome of an experiment made by one observer, located at one place, cannot be influenced by what another experimenter does, at the same moment, at another place. '(A more correct formulation would terminate with' ... **does**, at another place that is space-like separated from the former'.)

Note 5. It should be understood, that this firm statement expressed by Omnès (and in similar words by others as well), denies the possibility of a 'reality' in the usual sense, in which 'contra-factual reasoning' (such as: if, in place of doing 'this', and getting 'this' result, I would have done 'that', I would necessarily have got 'that' result) is perfectly valid, granted that it is logically sound. The virtue of Omnès' statement is, to circumvent the puzzles provoked by the appearance of 'non-locality', something that Einstein would have fervently welcomed. Alas; on the other hand, Einstein was also a no less fervent adept of logically assessable "elements of reality"!

In devotion to Einstein's genius, we should not pass in silence over some rather esoteric arguments (one or other of them could well, one day, become an accepted, perhaps even a corroborated theory!), brought forth during the past few years, which, if confirmed, would justify Einstein's views.

In favor of 'Reality' in the Einsteinian sense is a 'Gedanken'-[thought-] experiment, proposed by two prominent Israeli physicists. These authors assert, that the expected result of this experiment "provides a strong argument for associating physical reality with the 'Quantum state' of a single system, and challenges the usual assumption ..." (Aharonov - Vaidman, 1993). They stress, that recent experimental work holds promise of a possible implementation of their 'Gedanken' level experiment in practice.

More recently, David Deutsch (who may be called the 'father of the Quantum Computer' (see Deutsch 1985b), a powerful kind of computer, still in an embryonic state but holding great promise for the future) and his collaborator have likewise presented a mathematical scheme that aims at rehabilitating Einstein's views (Deutsch-Hayden 2000). In particular, the scheme presented by these authors eliminates not only apparent non-localities, but also the probabilistic nature ascribed to quantum physics. Nothing could have been more pleasing to Einstein, who never was ready to admit a possibility that "G-d plays dice".

Deutsch-Hayden's scheme postulates a completely deterministic course of natural processes. In the realm of Quantum physics, the scheme represents a kind of 'hidden variables'-theory. 'Hidden variables' theories have been proposed before; notably Bohm's 'Quantum Potential' theory, in 1952, after having 'proved', in his 1951 book, that "Quantum theory is inconsistent with hidden variables!" (Bohm 1951, p.622). The meaning of hidden variables is, that the apparently stochastic outcome of quantic events is, in truth, the statistical result of completely deterministic causes acting on individual particles. These causes are (still?) unknown ('hidden');

Deutsch-Hayden argue that the information about the imprint of those hidden variables, buried in the experimental results, is "locally inaccessible". Only by having recourse to classical ('local') information channels, can such 'non-local-looking' consequences of the hidden causes be revealed (l.c.). The authors contend, that the views held by scientists during the last two decades (i.e., since the famous experiment of Aspect et.al., in 1982, and repetitions in several variants, in its wake, became known), although they were much differing, were wrong, all of them being based on a common "false premise" (p.1772).

It has been remarked by M.A Rubin (2002), and others, that Deutsch-Hayden's scheme rests on the 'many worlds' interpretation of Quantum Mechanics Deutsch adheres to (see note [7]). This is a view not everybody will be ready to espouse; the epistemological price to be paid for the removal (afforded by these views) of the oddities inherent in 'classical'

Quantum mechanics, is very high (see, e.g., p. 196 below for an idea of what is involved).

Also, quite recently, during the (up to now) last of a long series of international conferences on the 'Foundations of Quantum Mechanics' held in the course of the last twenty or so years, the views of Einstein were again bolstered, while the various differing views that were predominant during those last years met severe criticism (Fuchs 2002). This is not the place to discuss such views; (see however my comment to Barret's book, p.198 below). I tend to think that they do not eliminate the conceptual difficulties; they only displace them to other grounds. This is so, in particular, for the elimination of 'nonlocality' (a main aim of Deutsch-Hayden's work). Is 'another world' a local entity?

Several other proposals have made their appearance lately. Thus, e.g., Howard's "backdoor connections" through 'wormholes' (quoted above, p. 184) would probably be judged as not in conflict with Einstein's views, (just as the precise spatial definition of an entangled 'particle', found in an experiment called 'Popper's test', is not to be considered a violation of Heisenberg's uncertainty principle).

Apparently, the issue is not closed. However, which one of the proposed schemes, (if anyone of them), might eventually gain general acceptance in the future, the result would **only make our world more mysterious!**

Note 6. Nonlocal phenomena appear when two or more particles are in a state of 'entanglement'. In principle, entanglement exists worldwide. All particles of same kind (e.g. all electrons, or all protons), all over the world, are entangled. (See, e.g., Peres 1998, p.128). This is "not a matter of concern" (l.c.) to the physicist, who's attention concentrates on particles in his laboratory; the identical particles far away ("on the moon"; yet, entangled with ours, here) will have no observable effects. It should however be of concern to the philosopher (and to us).

Nonlocal phenomena have been first observed with the so-called 'two-photons'; that is: two photons coming into being in a simultaneous emission from the same source. The source is either an excited atom or ion, emitting two photons in ‘cascade’, or a crystal having the peculiar property of ‘dividing’ an incoming high-energy photon into two low-energy ones, by the already-mentioned process of ‘spontaneous parametric down-conversion’. This fact suggested the extension (made in the text) to the whole Universe, since the latter evolved from a common source; viz, (purportedly), from the extraordinary space-time singularity called the ‘Big-Bang’.

After their first success in demonstrating the existence of entanglement, physicists have found ways to entangle particles (of various kinds), even when they do not stem from the same source (a possibility theoretically predicted already in 1935 by Schrodinger). In particular, they have discovered means to produce ‘swapping’, that is: exchanging one partner of an entangled pair with a foreign particle, such that the latter gets entangled with the other partner. With help of this process, the atomic state of a particle situated at one place can be ‘teleported’ to another particle situated at a remote location.

As soon as its first experimental implementation became public, the phenomenon, now called ‘teleportation’ became the subject of wild speculations, mainly of the science-fiction character. However, it is presently intensively studied, with an eye to possible future practical applications. “This process may look like science fiction, but it is a rigorous consequence of quantum theory.” (Peres 1998, p.296). Within the picture of ‘intrinsic unity of the world’, it looks rather realistic.

Note 7. The idea that the Universe we live in may not be the only one, but that there could possibly exist other universes, unperceived by our senses, has been advanced (firstly in the form of a scientific theory!) by Hugh Everett III (a disciple of famous Niels Bohr), in his Ph.D. thesis at Princeton University in 1957. Initially ridiculed, the idea has gained serious attention in recent years (albeit mainly in the form of vivid discussions about what Everett really meant with his “reformulation of Quantum Mechanics”). The theory was further developed by B.S. DeWitt and by N. Graham (in his Ph.D. thesis), published in a common volume (DeWitt-Graham 1973) and, later, supplemented “with some minor improvements” by David Deutsch (Deutsch 1984a; p.2).

The interested reader is referred to Barrett's book listed in the 'Further Readings' below for a review of various interpretations of Everett's thesis, as well as to a reflection of mine, appended there. However, since we had already occasion to mention the possibility of 'another world', in connection with 'spacetime foaminess', I would like to indicate two analogies, which might be of nature to make the idea of another world more 'tasty'.

1. When asked: "What exists ten centimeters from your right ear?", most people will answer: "nothing; except air". But this is not true! A whole world of sound is there! One needs only hold a transistor-radio there, in order to get aware of it. An analogous consideration applies to Television.

Our remote forebears, not yet in possession of electrical (not to say: wireless) equipment, could not have dreamed of an 'ether', bearing information from all over the world to everywhere else on earth. If someone would have been told, then, that with the help of a small 'simple' apparatus, humans will once be able to hear and see, in 'real time', what happens in any remote country on earth, this someone would most certainly have considered his interlocutor as completely mad.

2. Our bodies are pierced incessantly, throughout our lives, by an immense stream of elementary particles. These particles, called 'neutrinos' (there exists a whole zoo of them), are emitted by the sun, just as light is emitted. (Some of the neutrino species have a tiny (still unknown) amount of ponderable mass, others not). They interact so weakly with 'ordinary' matter, that almost all of those striking our globe, pass across it without leaving a trace. We are, unaware, literally immersed in that neutrino stream.

It is one of the great achievements of the human spirit, to have theoretically predicted their existence. And great expenditure of material means was required for the erection of the vast underground monitoring stations, deep under the earth's surface (some, dug out under eternal ice), in order to finally confirm the prediction of their existence. We live amidst a 'world' of particles we are unaware of.

Most remarkably, **that** little bit of interaction with other particles that allows us to detect them (by strenuous efforts only, though!) was also **just enough to ensure the possibility of our very existence.** "**If neutrinos had been slightly more slippery**, ... , we would not be here." (Jones 1996). **This** fact, of the precisely right measure of interactivity, pertains, in a sense, to the 'Anthropic Principle', who's essence bases on the observation, that the about-half a dozen of 'universal constants' known to us (Newton's, Planck's, etc.) have **precisely the right value to insure the existence of our world.**

This latter circumstance, too, has made the object of speculations around the possible existence of other worlds, governed by differently-valued constants.

If **we are** ready to believe in the existence of this kind of other worlds, physical but undetectable for us, we may utter the words of our daily prayer:

ריבון כל העולמים

"Lord of all worlds!"

with a little more of a concrete significance than we are used to.

Should we be unwilling to believe that, then we must glorify the Creator, the "Greatest Master of Calculation" (citing Rabbi S.R. Hirsch), that He has chosen exactly the right values for the 'universal constants', enabling us (living here on earth and, quite possibly, also creatures living on other celestial bodies) to exist.

Note 8. As if not enough that the General Theory lends grounds to an explanation of the puzzling instantaneous actions between entangled particles (by "backdoor connections"; see above, p.184), this theory allows the "foaminess" of spacetime engendering (in principle, at least) macroscopic wormholes. Such could even be constructed by humans of an "advanced civilization", (provided they dispose of the required superstrong materials), and used for "interstellar travel" (Morris-Thorne. 1987).

Let it however be stated here, for the sake of equity, that these latest, ‘exotic’ theories cannot be taken, the time being, as firmly (or, perhaps, even remotely) established.

I confess that initially I was strongly reluctant to include the last topics in my work. However, the erudite contemporaries of Jules Verne might have had similar feelings with respect to man’s landing on the moon. So, I don’t find sufficient justification for omitting them.

Further Readings

David Bohm & B.J. Hiley: **The undivided Universe** Routledge, London 1993

Jeffrey A Barrett: **The Quantum Mechanics of Worlds and Minds**, Oxf. Univ. Press c 1999-2001

The declared aim of the book (see its Preface) is to clarify the ideas advanced by the late Hugh Everett III in an attempt to solve a tiresome problem in Quantum Mechanics, called the 'measurement problem'. (In essence, it goes about the transition from the quantic to the classical domain in physics). To the problem of finding a mathematical formulation of this transition no completely satisfactory solution had been offered (and, in fact, still is not, at least not up to closure of Barrett's book), despite intense efforts. Everett advanced the vanguard concept commonly called "the 'many worlds' interpretation of Quantum Mechanics".

Everett's formulations have given rise to various differing interpretations. The one that is most bewildering holds, that the world we consciously experience, is embedded in an infinite manifold of worlds. The practical advantage, physicists want to draw thereof, is to enable them to explain, why an 'observer' (a physicist) always sees only one single outcome of an experiment, while Quantum theory postulates a combination ('*superposition*') of several different 'quantum states' to have only probabilities for each one of a number of possible outcomes. In order to maintain the continuous, 'jump'-less validity of the theory also for the state after completion of the experiment, (i.e., to establish the '*universal validity*' *of Quantum Mechanics*), Everett (in this interpretation) contends, that in truth all possible results predicted by the theory are in fact realized, albeit in separate worlds. The "identity" of an observer (or his "mind"), likewise is "split" into as many "copies", each one experiencing one of the different outcomes. (The terms within quotation marks are 'picked out' of several sources.)

I will confess that, despite much effort, I find myself unable to grasp the ideas of those distinguished physicists that defend this view. I think, however, that if serious scientists can believe this, there is no reason why we should not believe, that such ‘copies’ of our minds could well exist in another world, (after death or, who knows, even now).

Barrett’s book offers the service of giving the reader an overview, and a critical appraisal, of the various interpretations proposed; the whole embedded in a very readable account of the subject (with sparse use of mathematics). No doubt a valuable book for those interested to take a look into the “worlds and minds” of Quantum physicists.

Chapter X. Humans

Certain behavioral biologists ('ethologists') have a tendency to emphasize the importance of understanding the evolution of human behavior on the same lines as the evolution of animal behavior. This attitude has, in the first place, been strongly warned against. So, e.g., Kalmus (1957): "Conclusions drawn from observations or experiments with animals can be applied to man only with the very greatest caution" (p.28). Even the materialistic-minded Michael Ruse (see Note 3 of chapter II.) admits: "But it hardly needs saying that there are many today, even within the biological community (S.J. Gould and other eminent scientists), who are **extremely dubious** about the extent to which evolutionary biology can throw meaningful light on human nature" (Ruse 2000; p.22; my emphasis).

Secondly, and most significantly: emphasizing the importance of the animal side in human nature bears in it the danger of boomerang-like influence on human behavior, driving it in a retrograde direction. Human's nature excels in its flexibility and adaptability, far beyond animal nature, **for the good as for the bad**. Already we are witnessing such influence in the relaxation of moral standards in all spheres of human social life. Violence, corruption, drugs, sexual permissiveness, and the concurrent degradation of true love and marital fidelity spread in the 'modern' societies, causing decay of familial bond and of decent parental education of children. The harmful impact of all these on the quality of human life is recognized by all thoughtful persons. The more humans will try to understand themselves in the light of current evolutionary theory, i.e.: as animals whose nature consists solely in their tendency to promote their (inclusive) fitness [1], the more the trend of their behavior will degenerate, leading ultimately (G-d forbid) to kind of a (possibly very intelligent) '*pithecanthropus*'. Conversely, the more they will promote the awareness of their superior capacities, deriving from the spiritual source of their intellect, the higher will be their achievements in every respect. The intelligent human, be his faith what it may, should realize that there is an evolutionary kind of progress in the world we live in. Yet, this is not limited to the physical realm only. Human activity is destined to focus on mental and spiritual growth as well.

Therefore, the striving of man should be to transcend himself in respect to his present level, even though the ultimate goal is concealed to him. Yet, it is inherent in this process of ascent to higher levels, that the progress that can be achieved is dependent on the exertion of previously gained faculties; for human, in particular, of intellectual and moral faculties.

The question is: Can we do it? Do we have free will, enabling us to do it?

In the opening chapter we had emphasized the far-reaching meaning of Lima-de-Faria's thesis; i.e., the total channeling of all natural development, including the organic one. Otherwise said, the deterministic unfolding of the universe from its first moment on. We found this harmonizing with the Torah's words closing the Creation narrative: "... which G-d created for doing [so further-on]".

The statement that our intellect derives from the "Universe of Spirit" (we believe in; see chapter Vll), endowing us with free will, may appear as contradicting a thesis of completely deterministic evolution of the world from its beginnings on and up to now. However, we have already made a distinction between the purely material part (which may be completely determined), and the spiritual one. As for the latter, we, are in fact facing a dilemma. Either everything (including the mental processes going-on in our brains) is causally determined from what preceded, or: the course of evolution, of mankind at least, is decisively influenced by the measure in which the potentialities of the intellect are implemented in practice. It will be recognized that we are dealing here with the conundrum that occupied, yea tortured, the minds of religious thinkers since ever. It is the apparent incompatibility between G-d's Omniscience and man's free will.

In "classical" quantum physics (spoken-of in the preceding chapter) we had a somewhat analogous dilemma. It was the apparent incompatibility between the particle nature and the wave nature of the elementary particles and atoms. The means devised by scientists for resolving this dilemma are enlightening. It is the principle of '*Complementarity*'. This principle states that: "at the quantum level, the most general physical properties of any system must be expressed in terms of complementary pairs of variables, each of which can be better defined only at the expense of a corresponding loss in the degree of definition of the other" (Bohm, 1951, p. 160). In other words: the means for resolving the riddle of the true nature of the 'wavicle' (be it an electron, an atom, or whatever particle) is, to **renounce the pretension** of knowing its exact nature. Or, as Bohm expresses it: "A given system is capable, in principle, of demonstrating an infinite variety of properties that cannot all exist in simultaneously well-defined forms" (l.c.). This gives us already a strong lever for trying to cope with our spiritual dilemma. But we have a statement of more general importance:

"The real lesson to be learned from the principle of complementarity, a lesson that can perhaps be transferred to other fields of knowledge, consists in emphasizing the wealth of reality, which **overflows any single language**, any single logical structure." (Prigogine 1984; p. 225; my emphasis).

The incompetence of science to utter its 'verdict' about human nature has been openly declared by F.M. Harold, in the closing sentence of his book (we outlined his gloomy outlook on life in chapter VI.): "About what it means to be humans, individual scientists often hold strong opinions; but **science must be silent**". (Harold 2001; my emphasis).

These are strong statements, and they should be given their due weight. In view of this incapability to grasp the true nature of things, as expressed in the principle of complementarity (and as already generally accepted with respect to the most basic building stones of all existence), the claim of teleonomists to know for sure the stochastic origin of our intellect, (and therefrom its true nature), appears devoid of any firm rational basis.

We do not yet have such a universally recognized principle of complementarity for the somatic, psychic, and intellectual properties of living systems; its existence should not be excluded beforehand, however. As a matter of fact, Grassé states, right at the start of his important and encompassing work (out of which we had occasion to cite copiously in chapter 1: "Niels Bohr's principle of complementarity applies not only to the corpuscular and vibratory aspects of life, but also to living beings." (l.c., p.3) Here is also place for free will.

Free will is fundamental to man's consciousness of his moral responsibility. Sense of moral responsibility is an attribute of a highly developed intellectuality. 'Free will', per se, as an attribute of intelligence, opens up the possibility to choose between possible ways of action. This implies that, notwithstanding deterministic laws governing the material world, the course of human history was, in fact, influenced by the degree to which intelligence (including the respective prevailing levels of ethics and morality), determined man's actions, and his interactions with the material environment surrounding him. We may see herein an implementation of principle of "*Tzimtzum*" (hebrew צמצום). "Tzimtzum" is a central Cabalistic concept, rendered approximately by the term 'self-restriction'. This self-restriction, self-imposed by the Creator in order to enable the exemption of human action from determinism. Alternatively one can, perhaps, see herein, deeply concealed, a connection with the "indeterminacy" of quantum-mechanics, which leaves a certain amount of quasi "self-determination" to things of the inanimate world. Thus, for example, an unstable radioactive atom has a "self-determination" to disintegrate at this or that particular moment. According to Quantum Mechanics, this moment is intrinsically and utterly unpredictable. It maybe within a second, or after a billion years. (Of course, the term "self-determination" is used here as a metaphor, it is not meant to endow the atom with any measure of intelligence). What is remarkable however, is that, while for a single radioactive atom it is impossible to know at what instant it will disintegrate, for a gram (say) of this substance we can make precise predictions. Thus, the rate of disintegration (i.e.: how many atoms will disintegrate during the next hour, say, or the fraction of its weight that will subsist in a thousand years (say), can be predicted with great accuracy at any moment! Perhaps can we see herein a faint trace of the truth of G-d's Omniscience, concerning human history: It can be predetermined despite the freedom-of-will of the individual human.

Of course, we should be aware of the limitations of this analogy. The deterministic course of radioactive decay is based on the so-called 'law of great numbers'. Even a milligram of any kind of radioactive substance contains a huge number of atoms. (It is of the order of 10^{19}, a 1 with 19 zeroes after it!). At no time was the human population of the earth so numerous so as to fall in this category. Our example is not meant to be more than a prop. Of course, we should not want to understand divine attributes in depth. And in any case, we have to live our lives with the belief in our capacity to decide our actions. It may be that the ideas about the wholeness of the world and the incompleteness of human knowledge (see above, in this and in the preceding chapter) bear a key to a deeper understanding of this problem.

Tzimtzum enables mankind to evolve, not only along the strict lines of “laws of living organisms” (Grassé), but also (without violating these laws and, for that, any of nature’s laws) on the path, and in the measure, of deployment of intelligence and inventiveness. These are powerful tools in the hands of man. Their activation determines the pace of progress in the human sphere, boosted by man’s innate yearning for perfection, and his striving to approach it.

Striving for perfection is the very **antithesis to teleonomy**. It has its source in the “unseen Universe of Spirit” . Its fruits are the gigantic creative achievements of mankind, in all realms of human activities.

Man’s creative abilities are non-commensurate with those of any animal. We said before (at the close of chapter IV): man is a creation in its own right. For justifying this very ‘right’, we can invoke his special endowment: The gift of his creative powers. They derive, of course, from the Source of all creation, from the Creator.

But not only man; the whole living world strives to perfection, (albeit destitute of man’s creative power). The geologist W.O.Hotchkiss (1955) puts it nicely:

“The days of creation have been long and well filled with labor. Well might the ancient Hebrew prophet say, ‘He stood, and measured the earth; ... , and the everlasting mountains were scattered [shattered], the perpetual hills did bow; His ways are everlasting.’ [Havakuk 3]. We can see the labors of creation continuing before our eyes, if we can but enlarge our mental timescale to permit us to see present events in their true relation to those of long ago.” And:”It is as though the Creator had implanted a yearning for perfection in the first living things and we were privileged to sit and watch this progress from the crudest beginnings to the present through the whole long procession of a billion years”. Even Charles Darwin, in a letter (1878), leaves room to the doubt whether, (natural selection put aside), “there exists some mysterious innate tendency to perfectibility” (Cited by Pollack 1994, p.34).

The Torah opens its Creation narrative with a saying we have used in passing, opening chapter VII, and whose deep significance can perhaps be better grasped in the above context: "ורוח אלקים מרחפת על פני המים ... and the Spirit of Gd hovered over the face of the waters." (Gen. 1, 2). This hovering Spirit is at the root of Creation. It endows it with its properties and its laws, and -- with its striving to perfection.

In place of the complete randomness in evolution advocated for by classical and neo-Darwinism, modern scientists, like Grassé and Lima-de-Faria, have introduced partial, respectively complete determinism. Here, we have tried to put such predetermined, orderly evolution within the context of the Torah's characterization of divine Creation by the words: "אשר ברא אלקים לעשות" ("...That which God created for doing [so, further-on]".) These words express Creation, in His Free Will, through both divine Omnipotency and Omniscience, **and: --through his creatures' free will and creative power**. This feature, is expressed by the words:
"ויברא אלקים את האדם בצלמו" ("G-d created man in His own image"). 'His own image' portrays itself in our minds as: free Will and creative Power.

In chapter VI. (in particular), we have taken a glimpse at the marvels of life we are awe- struck by, and the many mysteries we cannot understand.

The biosphere of our planet can be likened to a huge pyramid. Its baseplate is formed by the microbes (a handful of topsoil houses millions over millions of them!), and by all the other unicellular creatures (a look at any tiny drop of water from the pond under the microscope will show you a crowd of them). The pyramid's body makes out all multi-cellular living beings. High, high on top of it, stands man.

As far as we can grasp the past and foresee the future, the pyramid is steadily growing in size and stature. Far from taking an attitude (as some of the 'behaviorists' mentioned at the start of the chapter do) of seeing in man an animal that 'happens' to be more intelligent than all the others, we have to see him (in a Lamarckian spirit) as the Leader of that pyramid of life; as the pioneer in its progress towards a future that, albeit unknown, is no doubt intended to become superior to its present state. How much superior, we cannot know. Perhaps, the speculations that closed the foregoing chapter might be apt to kindle a spark of a clue in someone's mind.

Notes to Chapter X.

Note 1. ‘Inclusive fitness’ means; Fitness measured by the success both in survival and in copious reproduction

Chapter XI. Creation

John Archibald Wheeler, the brilliant physicist of our time, has expressed views about Physics that have been characterized as transcending the realm of the physical, extending into the metaphysical.

In his book "At home in the Universe" (Wheeler 1994), after scrutinizing the most advanced (and most puzzling) experimental results in Quantum Physics, Wheeler comes to the following conclusions:

"A quantum phenomenon is an act of creation" (p.124).

"Of the signs that testify to a quantum phenomenon as being the elementary act of creation, none is more striking than its untouchability". And further:

"Until the act of detection [by irreversible amplification in our detectors], the [quantum] phenomenon-to-be is not yet a phenomenon" (p.123). "We are dealing with **an elementary act of creation.** It reaches into the present from billions of years in the past" (p.126, my emphasis).

It is a most remarkable fact, that we are able to trace this idea, expressed by Wheeler, further back to illustrious men of past centuries.

The idea of continuous creation has been uttered, long before the advent of Quantum mechanics, by one of mankind's greatest geniuses, Isaac Newton. He declared: "G-d can, by an act of will, momentarily render a region of space a bounded atom [i.e. He turns the void region into one containing an atom], continuous motion coming about by his successively so rendering immediately adjacent regions thus so bounded" (cited by Howard 1997, p.139, Note 11). In other words, this means that the process of movement of an object, from place A to place B (say), comes about by G-d's annihilating it at A, recreating and annihilating it at any immediately adjacent place, and so forth and forth, at all the points between A and B, until, eventually, it is recreated (without annihilation) at B.

(In this context it is worth mentioning that Newton's genius disclosed itself also in his preconception of light's nature as composed of particles, called 'photons' today. It was reserved to that other genius, Albert Einstein, to prove the correctness of Newton's conception.)

Wheeler speaks of creation without explicitly mentioning the Creator.

But are the insights expressed by Wheeler (and also by Bohm) not identical, in essence, with the teachings of Rabbi Shneur Zalman of Lodi, in his classic "תניא" (Tania)? Commenting there (Ch.1, and more fully in Ch.2 of שער הייחוד והאמונה) on the sentence: "לעולם אדוני דברך ניצב בשמיים" (Forever, O Lord, Thy word standeth fast in heaven), he says:

"...שטועים בדמיונם הכוזב שמדמים מעשה ה' עושה שמים וארץ למעשה אנוש ותחבולותיו כי כאשר יצא לצורף כלי שוב אין הכלי צריך לידי הצורף כי אף שידיו מסולקות ממנו והולך לו בשוק הכלי קיים בתבניתו וצלמו ממש כאשר יצא מידי הצורף כך מדמים הסכלים האלו מעשה שמים וארץ אך טח מראות עיניהם ההבדל הגדול שבין מעשה אנוש ותחבולותיו שהוא יש מיש רק שמשנה הצורה והתמונה מתמונת חתיכת כסף לתמונת כלי, למעשה שמים וארץ שהוא יש מאין, והוא פלא גדול יותר מקריעת ים סוף על- דבר-משל שהוליך ה' את הים ברוח קדים עזה... ואילו הפסיק ה' את הרוח כרגע היו המים חוזרים וניגרים במורד כדרכם וטבעם ולא קמו כחומה בלי ספק... וכל-שכן וקל-וחומר בבריאת יש מאין שהיא למעלה מן הטבע והפלא ופלא יותר מקריעת ים סוף על אחת כמה-וכמה שבהסתלקות כוח הבורא מן הנברא ח"ו ישוב הנברא לאין ואפס ממש אלא צריך להיות כוח הפועל בנפעל תמיד להחיותו ולקיימו ".

".... they imagine erroneously that G-d's creation of heaven and earth is comparable to the deed of a man; that like when a silversmith has finished creating an object, this latter continues existing independently of the smith, since when the latter leaves his work and walks away, his work continues existing in the exact form it was created. So these fools imagine the existence of heaven and earth [after creation]; they do not see the great difference between the creation by man, which is "something from something", with only its form and appearance altering from that of a piece of silver to that of a manufactured object, and the creation of heaven and earth which is "something from nothing", a miracle much greater than, by example, that of the parting of the Red Sea, when "the Lord caused the sea to go back by a strong east wind all the night, ...and the waters were parted"; and had G'd stopped the wind, the waters would have returned immediately, streaming down to their natural position. How much more, a fortiori, for the creation of" something from nothing" which is much more marvelous than the parting of the Red Sea, the retreat of the Creator's power from his creation would entail the annihilation of the latter; there must therefore be the power of the Creator, being steadily active in the creation, in order to maintain its existence and livelihood. (Free translation from the Hebrew).

Remarkably enough, precisely this idea, expressed by the 18/19th century Rabbi Shneur Zalman, has already been written down by the famous medieval Jewish thinker and poet, Yehuda Halevi (1080-1145), in his well-known religious-philosophical book “The Kuzari”. It may be presumed that both these scholars have drawn this lofty insight from an even more ancient common source.

Let us bear in mind that every happening, from the minutest to the biggest, is composed, in the last account, of elementary phenomena such as referred to by Wheeler. More than this: In the view of the modern physicist, even where we would perceive a completely void space, a perfect ‘classical’ vacuum, this ‘vacuum’ is to be understood as populated by an innumerable crowd of so-called ‘***virtual particles***’. “We now know something Faraday himself with prophetic genius anticipated: that empty space - what we call the vacuum - is not a passive receptacle devoid of properties, but a rich dynamic medium. It is filled, for one thing, with virtual particle-antiparticle pairs. These are quantum-mechanical fluctuations... “; (Wilczek and Devine, 1987). Bohm (1987) likewise conceives reality as continuous, ever recurrent “creation, sustenance and annihilation” of matter.

We realize: the whole universe is “living”; there is no single “dead spot” in the whole world. Coming into existence and fading away is perpetual and ever present! What exists, renews itself at every moment through the ever-creating Power of the Creator.

More particularly concerning evolution, a mutation occurring in a gene is an elementary phenomenon (most obviously so, when the mutation is caused by an elementary particle; yet in principle no matter what the precise cause may be). It is, therefore, an act of creation. Hence, the whole of the evolutionary process, as visualized by modern scientists, is disclosing itself as a continuous creative act.

We should recognize, then, the essential identity of Wheeler’s and Bohm’s conceptions, on the one side, and those of Yehuda Halevi and Rabbi Shneur Zalman, on the other side. What exists at any moment is created at that moment. Again, we gain insight into the Bible’s words:

אשר ברא אלקים לעשות **Creation is going on at every instant !**

We have to bear in mind, that what has been accomplished up to now by the human genius, however impressive, is not the ultimate. Future generations will probably judge, from their vantage point, the ‘state of the art’ of our days inferior to theirs, just as we today see that of past centuries. I can see no reason why we should not be aware of that, and, what more is, let ourselves be inspired by that thought. It should make us both proud and humble-minded; and it should let us feel our responsibility towards the generations to come. With this in mind, I find it most appropriate to close this essay by citing the words of the Ecclesiaste:

סוֹף דָּבָר, הַכֹּל נִשְׁמָע: אֶת-הָאֱלֹקִים יְרָא וְאֶת-מִצְוֺתָיו שְׁמוֹר, כִּי-זֶה כָּל-הָאָדָם

The end of the matter, all having been heard: Fear G’d, and keep his commandments; for this is the whole (essence of) man (Eccl. 12, 13).

Epilogue

Matter and spirit are incommensurable entities. Our present knowledge of the universe's immensity tells us, that our body (and, for that, our globe, the solar system, or even our whole galaxy) is infinitely small, in comparison.

The well-known thinker and writer Julian Huxley has appropriately remarked that, on an order-of-magnitude scale, man's size situates itself "almost halfway between atom and star". But the fact that we are able to appreciate this and, even, to make a (rough) quantitative evaluation of the size of the universe and the properties of its contents (galaxies, cosmic dust, radiation-fields, black holes, etc.), has to tell us that our mind is not "small" at all. This thought no doubt expresses itself in the answer of Albert Einstein to that astronomer who remarked to him: "To an astronomer, man is nothing more than an insignificant dot in an infinite universe". Einstein reportedly replied: "I have often felt that. But then I realize that the insignificant dot, who is man, is also the astronomer!"

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Appendix I: Timescales

In Chapter VII we touched on the difficulties encountered by scientists in trying to grasp the true nature of time as such. It is perhaps in place to consider briefly a special time problem, connected with faith based on the Bible.

There are religious people (both Jews and Gentiles), who are concerned about the enormous discrepancy between the age of the world resulting, naively, from the biblical narrative of Creation of the world in six days (closely followed by an enumeration of the first twenty human generations), and its age according to the time-scale established by modern scientists, ranging in the billions of years.

Various answers have been given to the question whether these widely differing pictures could be reconciled and, if not, what should be the stand of the believer. The answers given (ignoring the most extreme ones, which are beyond discussion) fall broadly into two groups: those which try to invalidate scientific age determinations (pointing to the unreliability of data gained with help of the methods employed by scientists, as well as to flaws in their arguments), and those proposing a scheme which contends to reconcile these two pictures of the world's remote past.

As for the first group, the general approach is to question the soundness of the scientific methods employed in dating the remote past. Subject to controversy is, in the first place, the premise of scientists that the laws of nature are immutable and, therefore, the rates of change of physical processes, as determined today, can safely be assumed to have reigned in nature since ever (to be exact: since a fraction of a second, or so, after the Big Bang). Now, the dating of events lying in the remote past necessarily has to rely just on this somewhat dubious assumption. Put into doubt already by the famous 19th century philosopher Peierls, this assumption is nowadays challenged by proposals discussed "in respectable scientific fora", to replace the notion of immutable laws by one "that endows them with an initial historical component" (S.S. Schweber, 1997, p.173).

The great question is, of course, the duration this 'historical component' had. Thus, if it could have stretched out into geological eras, then the by-far most important tool, used by historians, archeologists, paleontologists, geologists and cosmologists for age-determination in their respective areas of research, suffers from the weakness of that premise of the 'immutability of physical laws'. The mathematicien J.D. Barrow (Director of the Millenium Mathematics Project) says about the (assumedly immutable) universal constants of nature (see above, p. 196): "The constants combine our most precise experimental knowledge of the Universe with our most profound ignorance" (Barrow 2002).

That most important tool is ***radiometry***. Other methods, whenever used, also mostly rely for their calibration on radiometric means; thus, the latter are again a main factor in determining the reliability of those methods.

Radiometry, basically, uses the wealth of accumulated knowledge on the rates of decay of radioactive chemical elements. Mathematical relations between the empirically found present amounts of atomic decay-products and their source elements ("parent/daughter ratios") enable, in principle (and again: subject to certain premises; see below), calculation of the time span since the beginning of the decay process, given the (purported) knowledge of what were the decay-rates all along the process.

Plainly, by lack of knowledge of numerical values characterizing the mentioned 'historical component' of the decay-rates, scientists are reduced (at least up to the present) to base their calculations on the assumption of immutability of atomic decay rates. Moreover, quite a respectable number of supplementary assumptions (besides said immutability) have to be made by scientists in order to enable them establishing their figures. Not the least of these, in a radiometric age calculation, is an assumption necessarily to be made, due to lack of knowledge of the initial parent/daughter ratio (or, in the general case, of the ratios between the quantities of the various isotopes, involved in the decay process, which were already present originally in the material to be dated). Of course, this ratio is (resp. these ratios are) essential in starting the age calculation. But, clearly, nobody can know it (them) for sure, so one is forced to have recourse to various conjectures. In order to buttress these, such conjectures are frequently underpinned by empirical data from various different branches of knowledge. Here resides another source of error: the use of incorrect data, or wrong interpretation of even correct data.

While, therefore, contests made against the correctness of present-day archaeo-, and geo-chronological determinations appear to be justifiable, in principle, it may be doubted whether this alone (unsupplemented by further, more convincing arguments) could possibly bridge the huge gap and bring the biblical account, taken literally, into harmony with a more correct scientific knowledge.

Turning to the second group, many proposals have been put forward, mostly pivoting on the proper meaning to be given to the word “day”, in the Bible. Amongst the most prominent modern interpretations ranks, no doubt, the book of Gerald L. Schroeder: “Genesis and the Big Bang” (Schroeder 1992). Schroeder bases his explanation on the relativistic time dilatation, spoken of in chapter IX. In fact, it is an easy matter to let a short time-span appear elongated (dilated) to any desired extent, simply by changing-over to a reference-frame moving at sufficiently high speed. In this way, Schroeder thinks, the six days of creation, as seen from the Creator’s reference frame, appear in our human reference frame as billions of years.

The explanation which most fits my personal view is as follows: We have to distinguish between historical times and prehistorical ones. These may have different time scales.

The Bible, essentially, deals with historical events, not prehistorical ones. The five books of the Thora, which open the Bible, are in the first place a legal-moral codex. The first book, Genesis, opens with the Creation story.

There is the well-known saying of the talmudic scolar Rabbi Itshak: (Isaac), that the Thora should have started with the book Exodus (actually, with the commandment of determining the role of the new moon in fixing the calendar of the Jewish year; Ex. 12, 1.). The classical interpreter of the whole of Jewish heritage, Rabbi Shlomo ben Itshak (‘Rashi’), opens his Tora commentary with precisely this declaration. The concise sketch of the world’s initial course, after Creation of “Heaven and Earth”, is therefore to be understood as an appendage (although at the start), included for didactic (and possibly other) reasons. It is certainly not for teaching us cosmogony or natural history. Here, and for this purpose, a contracted time scale is used. An era of Creation is called a ‘day’.

It is quite evident that the term ‘day’, used in the context of the narrative of creation, cannot mean an astronomical day; the sun was created on the fourth ‘day’ only. The Bible ‘borrows’ the astronomical (and common language’s) term ‘day’, to designate a certain period of creation.

History begins with the appearance of the first living being endowed with the ‘image of G-d’ (בצלם אלקים)

This is rightly so; because history is not simply a sequential enumeration of events having occurred in the human realm. History, well understood, is in the first place Geistesgeschichte (‘history of the spirit’); that is: a record of the various currents in human spiritual life, its aspirations, its religious, philosophical, ideological and socio-political endeavors which, all, were at the base of the actual historical events, and which drove them from mankind’s beginnings on, and up to its present state.

The emergence of the ‘image of G-d’ (it has been qualified in the main text, p.151) in a living creature occured, according to the Bible, near the decline of the sixth ‘day’ of Creation. **From this time onwards**, the use of the usual (i.e., astronomical) time-units (days, months, and years) for historical records is the only suited one. Scientists use these units equally for prehistorical records; but this is in no way compelling, except for reasons of uniformity and continuity. Were the latter not essential for systematic study, other time-scales might be used (not without some logic, seen the hypothetical nature of scientific dating; see above).

Geologists subdivide the earth’s ‘history’ into eras, periods, etc. The Jewish calendar presently counts the year 5770 ‘*anno mundi*’ (‘since creation of the world’). Significantly, we **cautiously** specify in our ‘Ketuboth’s (wedding contracts): “according to the counting **we do** count”! We have to understand this count, more precisely, as meaning: “since completion of the Creation of the world”, i.e. since the beginning of history, in the sense stated. Creation itself, natural history, and Homo’s prehistory, ‘six days’, **not included!**

When scientists determine time spans ranging in the millions and billions of "years BP" (BP = before present), a difference of 5760 years is of no practical significance; in fact, it lies within the error margin of the scientific data. Therefore, we may retain the scientific notation 'BP', interpreting it as "Before Paradise", without deviating noticeably from the scientific age determination. The statement: "the Big Bang took place fifteen billion years BP" is the same, for all practical purposes, whether the P stands for 'Present' or for 'Paradise'. The billions of years 'before Paradise' are congruent with the six 'days' (eras) of creation.

There is a point that should be taken into. account, quite generally: It would be ridiculous to expect the Bible's narrative of Creation to parallel, in any measure, the Big-Bang story as it is running today. As the late Rabbi Dr. Joseph Breuer (my ancient teacher in Frankfurt a/M, his later years living in NewYork) used to say:

"The Thora does not want to tell us **how** G-d created the world, but rather **that** He created it".

This is the fact that imports for the sequel of the main text; and **it is told, narratively, in common man's language.**

דברה התורה בלשון בני אדם ("The Thora spoke in the language of people"; a frequent comment of our sages to passages quoted from the Bible).

Appendix II: Extraterrestrial Intelligence

Presently, the search for life (in particular: for human-like intelligent life!) is not any more restricted to places on earth. Search for intelligent life beyond earth is well under way; the chances for finding out are non-negligible (as we shall see).

I want to say, from the start: Should we, one day, be apprised of extraterrestrial intelligent life, this would give me a feeling of deep satisfaction. It would provide me with an answer to the haunting question: For what purpose did G-d create this unfathomably vast universe with its uncountable stars, if Spirit comes to its physical embodiment only on this speck of dust (on a cosmic scale), 'Earth'?

At present, we are in the era of incipient spaceflight. To ponder about 'extra-terrestial life' (life outside Earth) does not really mean anymore 'leaving firm grounds'. It is worthwhile, therefore, to enlarge our spiritual horizon by considering for a moment the extent of our present knowledge about the physical cosmos and its potentialities for life 'out there', perhaps on some distant planet.

We should first note that manned spaceflight to 'extrasolar planets' (i.e., planets orbiting around stars other than the sun) seems to be beyond any technical possibility. But people like us, who are aware of a past of several thousand years (not to mention paleontologists and evolutionists, who delve much deeper into the past!) should not shun from thinking about developments that have a certain chance to happen in a somewhat remote future. Therefore, we shall take a look, here, on the prospects that life might exist elsewhere in our cosmos, and that we might get knowledge thereof. A further goal that may be envisioned, is the exchange of information (although the speed of transmission is, as we have seen, restricted to that of light).

In our solar system, besides Earth, the planet Mars is the only one offering a minimal opportunity for sustenance of some rudimentary form of life. A landing of an unmanned spaceship on its surface has already been achieved. The event of 'man landing on Mars' is only a question of time. However, it can hardly be hoped to find there beings with human-like intelligence. But exactly **this**, the possible existence of extraterrestrial beings with human-like (or higher!) intelligence, is the question that fascinates space-scientists most. It is not a vain question. Man deploys gigantic efforts in order to have a chance to find out!

Extra-terrestrial life (specifically: 'extra-solar-system life'), at the human level, must be searched-for in other planetary systems (i.e., stars with orbiting planets), granted that such systems exist.

Only up to some fifty years ago, such thoughts were of no practical interest to scientists. The chances for such existence were judged as being nil. The old theory of the formation of planetary systems, that had been formulated by the great 18th century mathematician Laplace, was abandoned then. The idea favored by 20th-century cosmologists was, that the very existence of the earth (and, for that matter: of all of the sun's planets) was due to a unique cosmic event; namely: the nearby passage of another star near ours (the sun). The gravitational pull (force of attraction) that had acted between them at 'near passage', had extracted from the sun's bulk some clumps of matter which, in the course of time had formed the sun's planetary system, including our globe.

It was calculated, at that epoch that the chances for a repetition of such a close passing-by of two stars were negligible. Consequently, no other stars featuring a planetary system were believed to exist, at least not in 'our' galaxy (the galaxy to which our sun belongs; other galaxies are much too far away to speak about the motions of their individual stars).

Alternative theories about the natural evolution of 'young', very hot stars, eventually came up. With these, processes that could lead to planet formation became more plausible. At once, the interest in a search for extra-solar-planets (i.e. planets of other stars) grew tremendously, together with the urge to inquire into the possible existence of intelligence, there.

Our galaxy, the 'milky way' (it looks so milky in night's heaven because of its many stars, crowding the heavens, forming, roughly, a disk shape), contains about "200 to 400 billion".) Many astronomers cherish the idea that among this multitude of stars, **very many** feature a planetary system not unlike that of our sun. If only one out of a million; of these many billions of stars, had a planet with earth-like conditions, this would mean hundreds of thousands of candidates for the existence of life. In fact, the renowned physicist Robert Jastrow has estimated, on quite general grounds,that our galaxy alone (not to speak of the almost infinite number of other galaxies in our universe) might contain about one hundred thousand earth-like planets (Jastrow 1967, p.138).

Strangely enough this estimate is contested from both sides. Some would consider it grossly exaggerated; yet, to the Australian mathematician Dr. Andrew Prentice, of Monash University, it appears a gross underestimate. Prentice presents good reasons for his assumption that there are many more than this. Prentice revives the original Laplacian theory, which was believed untenable at the time. He amends it by the concept of "supersonic turbulence stress". According to Prentice's theory, a planetary system should be the **normal 'apparel' of every sun-like star** in our galaxy.

Prentice has already registered two successes:

1. On the grounds of calculations based on his theory, Prentice predicted the existence of four further large moons of Neptune, in addition to the two well-known Neptunian moons, Triton and Nereide. These additional moons were in fact discovered by "Voyager 2", corroborating Prentice's thesis.

2. While this turnover in the theory of planet formation took place during the later half of the 20th century, it is only about a decade or so, since astronomers were given tools enabling them to conduct an active search for '*exoplanets*' (short for 'extra-solar-system planets'). Search of that kind is well underway, now, at several observatories on earth, using different methods of observation. In fact, about a hundred planets have already been discovered to this date. A star with a planetary system **similar to ours** has recently been discovered. Likewise, an 'exoplanet' having an atmosphere has been found.

If Prentice's conjecture is correct, earth-like planets in our galaxy could number in the millions! A small fraction of these, at least, may well have earth-like ecological conditions (an atmosphere, water and solid ground, etc.). Water molecules are abundant in space; so, the presence of this vital element, in the form of gathered water, on earth-like exoplanets is at least imaginable.

A search for such earth-like exoplanets is at the focus of NASA's space mission, named 'Kepler Mission', launched in December of 2001. Its space-telescope is scheduled to observe ("almost continuously") during the course of four years, and examine the brightness variations (indicative of the passage of planets, if they are periodic) of about hundred thousand stars in our galaxy .

When one day, in the remote future, an intelligent message emitted from an exoplanet will be captured by our antennas, what kind of life might it disclose? Can we exclude the possibility, that intelligent beings, perhaps endowed with an intelligence much higher than ours, were their sender? There are some reasons for us to believe this! The known phenomenal prodigies of calculation (some of them deprived of any formal education), seem to prove that **even the human brain**, in exceptional cases, is capable of stunning performance. A number of such prodigies in computation and memorization have come to light in the last few centuries. A modern memory prodigy named Kim Peek, has been reported. He "is developmentally disabled [reminding us of the famous Steven Hawking?], knows more than 7600 books by heart as well as every area code highway, zip code & television station in the USA" (Treffert & Wallace, 2002).

What if not only one individual out of many millions, but a significant fraction of a population on an exoplanet were to possess such prodigious mental capacities (or perhaps even higher ones)? Telecommunication, by one or the other means, may one day prove successful in bridging the large gap between them and us.

Large antenna-arrays for reception of radio signals arriving from outer space have been erected for watching the sky. And they are operating, relentlessly 'hearing into the skies'.

There is, at least, the great project **SETI** (Search for ExtraTerrestial Intelligence), operating now about 40 years, looking for intelligent signals coming from space. SETI makes use, for that purpose, of several of the great radio-telescope antennas existing all-around the earth.

In addition such search is conducted using optical telescopes in several countries, probing the possibility that powerful laser signals might be emitted by intelligent beings on a remote celestial body, expressing some logical message. Such signals might one day reach the earth, and be detected by us.

Those who think that all this to be pure fantasy should consider the fact, that the members of the bodies deciding on allocation of the necessary funds for such enterprises, supposedly reasonable and cool-headed people, have approved the necessary allocations, and probably will continue to do so in the future. It can be concluded therefrom, that the chances, that one day, in the not too remote future, some kind of contact with extraterrestial intelligent beings will become a reality, are judged non-negligible by very sensible people.

Imagine for a moment, that such a communication with highly intelligent 'aliens' will once be established. How would we, humans, feel when finding ourselves faced with beings wiser and cleverer than us; beings who knew better than we, how to develop and materialize their inborn intellectual potential? Would Mankind not feel a retarded species, seized by remorse, perhaps, for not having used its time to do better, by using its inborn capacities for making progress instead of squandering them in arms-races, wars, etc.?

Contrary to the earlier conceptions in evolutionary biology, according which life on earth emerged thanks to an extremely improbable chemical event (a "frozen accident", say), modern scientists tend more and more (whatever their reasons) to espouse the view that the emergence of life was much to be expected (we saw examples of such theories in the first chapter). This given, the existence of life, and of consciousness, on earth-like galactic exoplanets should be no less expectable. An estimate of the cosmologist Raz Tamir, made on the basis of data gathered during the years of SETI's activity, yields the result that "about ten thousand civilizations" can be expected to exist on exoplanets, in our galaxy alone. Out of these, a considerable number of planets presumably have been formed at about the same time. Yet, "about the same time", in cosmogony, tolerates differences in the range of a few thousands or tens of thousands of years. It seems therefore a sound conjecture, that part of these earth-like planets, formed earlier than the Earth by as much. The civilizations evolved on them might therefore be tremendously in advance of ours.

We may also remember, that a few finely engraved metal plates are now underway, lifted into space by two of the first space missiles launched by man. The engravings are of such nature as to be intelligible to intelligent beings. (Thus, one of them depicts our solar system; another: Adam and Eve, before Fall.) True, the chances that these plates will one day be captured by intelligent beings are utterly small. That despite that the project was funded, shows the vivid interest taken in the matter.

Great projects for improved means of observation are planned, or their construction is already underway. Thus (in the wake of the successful 'Hubble' space telescope, which has already furnished invaluable pictures of previously unknown details of remote celestial bodies), "second generation" space telescopes are planned to be placed in orbit during the next ten to twenty years, by both the USA and Europe. Huge interferometric telescopes, capable of ten-thousand- to hundred-thousandfold more powerful picture resolution than those of today, may be expected for the middle of the century. Tools of this kind will enable to discern topography and, possibly, vegetation, on distant planets. Such planets, once pinpointed, will be the preferred objects for watching for intelligent signals (e.g., signals similar to the Morse code, which was the first tool of telecommunication on earth), and, perhaps, for directing towards them such signals from earth.

Following the general line of thought of this essay, faithful people should have no reason to reject these ideas. His Wisdom, His Intelligence, and His Creative Power are One. Why should the emanations of These be limited to the realm of this minute speck in the Universe: Earth?

I refrain from indulging in speculations (coming to one's mind, nolens volens) about far-reaching meanings, and consequences, of such possible future developments. However, I do stress that we ought to keep in mind that the 'Weltbild' (mental picture of the world) of our descendants, some dozens of generations ahead, might well be quite as much different from ours today than ours is from that of stone-age man. Our ancestors, only a thousand years ago, could not have, imagined, even in their wildest fantasies, the technical achievements of our time (telephone, television, jetplanes, satellites, space stations, internet; to name only a few), things that are commonplace today; not to mention landing on the moon. 'The science fiction of today will become the reality of tomorrow.' This can be said in a quite general way (not for all of science fiction,of course!). To be more specific, the issue of contact with extraterrestrial intelligent beings is "hot". If, and as soon as, such will happen, it will be another "Great step for mankind" (remember the first landing on the moon?); this time, a great step in 'Intelligent Evolution'.

Daniel S. Goldin, past administrator of the 'National American Space Agency', NASA, has expressed himself in the following words: "Finding life elsewhere would change everything -- **no human endeavor or thought would be unchanged by that discovery"** (Angel & Woolf, 1998; my emphasis).

Glossary

[q.v. abbreviation for quod videas 'look at it']

Amino Acid - chemical acidic compound, whose main constituents are a group of atoms called an 'amino group' (an organic derivative of ammonia) and an organic acid. Main constituent of protein.

Archeobacteria - (also spelled 'archaeobacteria'); very archaic organisms, still extant, thought before to belong to the bacteria, but lately recognized as being a separate domain, now called 'Archaea'. One of the most archaic domains known.

BP - Acronym for Before Present.

Carnivorous - flesh-eating

Chiasma - (pl. chiasmata); crossover of two arms of a homologous (q.v.) chromosome pair; in general, leading to 'recombination' (q.v.).

Cordata - the group comprising all animal species featuring a spinal chord.

Chromatid - single strand of DNA (q.v.); bearer of genes.

Chromosome - thread composed of one or two chromatids (q.v.), and proteins.

Codon - a set of three definite adjacent nucleotides (q.v.), coding for a given amino-acid (q.v.).

Conundrum - a puzzling (and, in all appearance, insolvable) problem.

Cosmogonic - the branch of physical science dealing with models of the possible origin, and early history, of the cosmos as perceived by us today.

Cosmology - the branch of physical science dealing with the nature and history of the cosmos (or universe).

Cytochrome c - a protein, copper containing, widely distributed in living cells.

Cytokinesis - (cyte = cell, kinesis = movement); the movements occurring in the cytoplasm (q.v.), deforming the cell walls, on the way to cell division.

Cytoplasm - the content of a cell, except its nucleus (resp. nuclei, in certain organisms).

Dimer - molecule composed of two chemically equal parts.

Diploid - said of a cell containing a double set of chromosomes (q.v.).

DNA - (Deoxy-Ribo-Nucleic acid); biologic, linear (chain-like) macro-molecule, various stretches of it being 'genes' (q.v.).

E. coli - (Full name: Escherichia coli); species of motile, rod-shaped bacteria. Extensively used in genetic research. .

Electron - the most ubiquitous elementary particle, constituent of all atoms. Put to use in all electrical appliances. The electrical charge of the particle, conventionally called 'negative charge', serves as a natural unit thereof

Entropy - a mathematically definable measure of the disorder in, (resp. the lack of information about), a composite or multi-partite system.

Epigenetic - connected with the genetics of an organism, yet being beyond the frame of the branch of genetics proper.

Eukaryote - an organism whose cells comprise at least one nucleus (as is the normal case in higher, multicellular organisms); eukaryotic nucleus-containing; (the term characterizes a cell type).

extant - still existing; (either meaning: still today, or still at a time in the past, spoken-of or said of archaic objects or beings).

Gamete - mature germ cell (male or female), ready for fertilization.

Gene - a unit of genetic (hereditary) information, encoded in a well-delimited stretch of a molecule of DNA (q.v.). Main types: functional genes (encoding for proteins) and regulatory genes.

Genome - the full set of genes (or of genetic information) of an organism.

Genotype - the type of a gene (q.v.) that determines, or influences, the phenotype (q.v.) of its bearer.

haploid - said of a cell containing a single set of chromosomes (q.v.).

heliotropic - the property of a plant, where the upper part (e.g., a flower-head) tracks the sun across the sky.

homologous - (in Genetics:) said of two chromosomes (q.v.) within a cell that contain the same genes, one of paternal, one of maternal origin.

Interstice - free space between amassed clumps of material of any kind and size (incl. between the atoms, resp. molecules, of a body).

Ion - an atom or molecule that is electrically charged, either by having been stripped of one or more of its electrons (positive ion), or by having ‘caught’ one or more electrons (negative ion).

Lacuna - (pl.: lacunas or lacunae); gap, deficiency.

Lepton - any member of a distinct group of low-mass elementary particles (electron, muon, tauon; and their associated neutrinos).

Lysozyme - anyone of a class of enzymes produced by mammalian organisms, provoking immune response against bacterial attack.

Macroscopic - (macro = large); 'visible to the naked eye'. More specifically: said of an object that does not require a microscope in order to be seen by the human eye. (q.v.)

metabolic - pertaining to metabolism (q.v.)

Metabolism - the totality of physiological processes occurring within a living organism. More particularly, those processes that serve to sustain life, such as the intake of oxygen and the digestion of food.

morphological - pertaining to the morphology (q.v.)

Morphology - (in a restrictive sense:) the outer appearance of a body. (In a more general sense:) all the detectable bodily features of an organism

nascent - in the process of birth, or, of coming into being.

Negentropy - negative entropy (q.v.); a term coined by Erwin Schroedinger for the purpose of introducing a measure for the degree of order (as opposed to 'degree of disorder'). The term is not widely used.

Neutrino - the most elusive kind of the 'elementary particles'. Their existence, theoretically predicted decades ago, was experimentally ascertained in full only recently, thanks to huge expenditure of effort. Several types, all electrically neutral, of either zero or extremely smaIl rest-mass (q. v.). Emitted by the sun, those reaching Earth penetrate across, leaving it quasi undisturbed.

Neutron - a neutral elementary particle. Neutrons constitute, together with protons (q.v.), the nuclei of all atoms (except the nucleus of the hydrogen atom, which consists of a single proton). Electrically neutral, the neutron has a magnetic moment (it behaves like a minuscule magnet). Its mass exceeds very slightly that of the proton.

Nucleotide - (in Genetics:) a rather complex chemical compound. Two nucleotides constitute a 'base pair', i.e., one of the many links making out the chain-like molecule of DNA (q.v.).

ontogenetic - pertaining to the ontogeny (q.v.).

Ontogeny - (in Biology:) the whole course of an individual organism's development, from the zygote (q.v.) to the mature organism.

ontological - pertaining to ontology (q.v.)
Ontology - the science, or knowledge, about all that is in existence

Oocyte - the immature ovum (q.v.).

Organelle - ('small organ') a structural part of the cell within its membrane, performing a specific function

Ovum - (egg cell); female gamete (q.v.)

Paleo – 'very old'; pertaining to geology or prehistory

Parsimony - Parsimoniousness; (in evolutionary theory:) the principle of choosing that particular phylogenetic (q.v.) reconstruction scheme whose branching pattern requires the smallest possible number of evolutionary changes, as the one that represents what has actually occurred in evolutionary history.

Phenotype - the observable characteristics of an organism; (as distinct from its genotype (q.v.) that has an influence on that characteristic).

Photon - a ‘quantum’ (q.v.) of electromagnetic radiation.

phylogenetic - pertaining to phylogeny (q.v.).

Phylogeny (also: phylogenesis); evolutionary history as depicted by current theory; namely: as a tree-like deployment of living forms, grown gradually by branching-off of differing descendants from a common ancestor.

Pithecus - ape

Pithecanthropus - ape-man

polygenic - said of a property (character, trait) which is uniquely determined only by more than one gene.

polyhedral - in the form of a solid body with rectilineal edges enclosing planar facets (called a polyhedron).

Polyploid - the property of a living cell of containing more than two sets of chromosomes (see entry ‘diploid’).

Polymer - a substance composed (mainly) of molecules that are ‘built up as a chain of identical repeating units (called monomers).

Positron - an elementary particle; the ‘antiparticle’ of the electron. It has the same mass as the electron, and an electrical charge of same magnitude but opposite (‘positive’) sign than the electron’s (‘negative’) charge.

Prebiotic - before the existence of life on earth.

Primordial - in a primitive state.

Prokaryote - an organism whose cells contain no nucleus, the genetic material free-floating in the cytoplasm

Proton - the nucleus of the hydrogen atom. Being the lightest of all atomic nuclei, it is considered an ‘elementary particle’. It has a positive electrical charge, of same magnitude as the electron (q.v.), such that the atoms are electrically neutral (having always the same number of protons and electrons).

Pseudopod - legless animal, having the faculty to extend movable protrusions .from its (normally) unicellular body, enabling it to progress.

Quantum: ‘the minutest possible quantity’. Applies to energy in all its possible forms (radiation, work, magnetic flux, etc.), and to angular momentum (orbital and intrinsic). It is a basic insight, afforded by Quantum theory, into the nature of radiation (light, radiant heat, radio waves, etc.), that it cannot exist in arbitrarily small (up to vanishing) amounts. It comes in discrete lumps (‘quanta’) of a definite energy. One such lump of radiant energy is called a photon.

Quark - any member of a group of six subatomic particles, today strongly believed to be amongst the most fundamental constituents of matter. Protons and neutrons should contain, each, three quarks. [The electric charge of a quark is believed to be either one third of a protonic, or two thirds of an electronic charge; thus, the combination of three of them can make out either zero (neutron) or full (proton) charge.]

Recombination - an exchange, between homologous chromosomes, of parts of their ‘arms’; initiated at a chiasma (q.v.).

Reductionism - (in biological sciences:) the doctrine that all biological processes can, in the last instance, be explained by (i.e.: ‘reduced to’) physical and chemical processes .

Rest-mass - mass in the usual sense (to distinguish from the relativistic mass increase of a body in motion).

Ribosome - an organelle (q.v.) containing RNA (q.v.); plays an important role in the process of protein (q.v.) production, in accordance with the genetic information deposited on it by a molecule of mRNA (q.v.).

RNA - (Ribonucleic acid) a molecule chemically akin to DNA (q.v.); it exists in several variants (mRNA = messenger-RNA; tRNA = transfer RNA; rRNA = ribosomal RNA), according to function.

Saltation - (‘jump’); a term used by evolutionists for the occurrence, within a relatively short evolutionary period, of major evolutionary change.

Somatic - pertaining to the body, as distinguished from the mind; or: to the cells of a body as distinguished from the germ cells, (which latter form a separate line, the ‘germ line’).

Spatial - relating to space.

Spermatid - the male germ cell in the state of an immature sperm.

Spermatozoon - the final form of a sperm (q.v.); it is an animalcule, apt to move within its natural medium.

Stasis - a relatively extended period in evolutionary history during which no major evolutionary change has occurred (vs. saltations; q.v.).

Status Nascendi - the nascent (q.v.) state.

Stochastic - occurring in a random way, without regularity or rule of any kind, yet allowing for statistical elements of probability to be known. The expression ‘chanceful stochastic’ means that the potentiality of being chanceful , inherent in the statistical elements, has in fact been realized.

Strand - one fibril (‘thread’) of a double (or multiple) stranded molecule.

Superluminal - ‘faster than light’; said of a phenomenon (e.g., a signal, or a wave motion) progressing in space with speed higher than the speed of light.

supra- beyond, exceeding.

Symbiosis - life partnership between two (or more) organisms, providing advantage to one or both of the partners (sym = together; bio = life).

Taxon - (pl.: taxa); the totality of organisms belonging to a given taxonomic (q.v.) entity. The main taxons, in evolutionary order, are: {Domain (a relatively new taxonomic term); Kingdom, Phylum; Class; Order; Family; Genus; Species}.

taxonomy - The branch of biological sciences dealing with the classification of organisms.

Teleology - the interpretation of animal or plant structures and functions in terms of purpose and utility.

Teleonomy - the doctrine that the purposefulness, appearing in form and function of living things, is only an impression arising from the adaptations brought about by stochastic (q.v.) variation of genetic material, followed by natural selection.

Zygote - fertilized ovum (q.v.).

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