FERNANDO DE ANGELIS

THE ORIGIN OF LIFE BY

EVOLUTION: AN OBSTACLE

TO THE DEVELOPMENT OF SCIENCE

Translator: Leigh Pennington

To Gilda, truly «*flesh of my flesh*» *(Genesis 2:23)*

Fernando De Angelis was born in Cascia (Perugia), Italy in 1946, and after graduating in Agrarian Sciences from the University of Perugia he dedicated himself primarily to teaching Natural Sciences, Chemistry and Geography in Italian high schools.

While at university his contacts, first with the Gospel and then with evangelicals, led to a radical change in his way of thinking and living.

He has dedicated himself to the defence of the cultural validity of the Bible and after having worked for the spread of creationism in Italy, he is now preparing a textbook on geography and history.

In 1970 he married Gilda, and at present they live in Cortona, near Arezzo, in central Italy.

PREMISE FOR THE INTERNET VERSION

First of all I would like to thank the Centre of Creationist Studies (CSC) and its President, Romano Ricci, for having decided to put this study on line. he text of this version is that which was printed by Frederick L. Whitman in an unpublished form. In that text there is only one illustration and it is not indispensable. We have eliminated it to facilitate the circulation of the text electronically.

Anyone can copy and have copies made of this text, without the need of authorization. The author's permission is necessary only for whoever might desire to print an edition of it and for whoever might, in some way, desire to sell this work.

Whoever might desire a copy of the work by means of internet can contact the site: www.creazionismo.org , or write directly to the undersigned.

Camucia di Cortona (AR), lì 26/12/2000

Fernando De Angelis
Casella postale 92
I - 52042 CAMUCIA (AR)
ITALY

FOREWARD

I had already struggled through my evolutionary high school biology course in 1964 when I came in contact with a book that dealt with the creation-evolution debate from a biblical and scientific perspective. It had not been difficult to deny the theory of evolution because I knew that it went against the Scriptures, but my defence of creationism left a lot to be desired.

Since those mid-sixties, the Christian school movement and various creationist societies have worked hard in the production of many great texts dealing with the theme of creationism as well as exposing godless evolutionary theories. One might ask if there is room on the shelf for another book of this nature. I believe there is!

After first reading this treatise in Italian, its contents enthused me so much that I encouraged Prof. Fernando De Angelis, my esteemed brother in Christ, to consider having it translated into English. This was indeed a switch since up to this point we had always been involved in the translation of English texts into Italian. So why go to all the work of having an Italian book on the creation-evolution theme translated and printed in English when we already have so many? In my opinion, this book, in its European approach to history and its clear and historic presentation of creationism's influence on the development of science and medicine, has filled a void left by other books written on the subject.

Some of the historical facts that are reported in the book could be offensive to people with an ecumenical mind-set but a thorough knowledge of history is one of the best defences against falling back into the same errors of the past. Truth will triumph. For the record, no Italians were offended by the historical facts that were presented.

It is my prayer that as this book is read. God's people will be encouraged in their testimony of the truth and the spread of the Gospel “once and for all delivered to the saints”. This Gospel is not complete without a clear and unadulterated approach to the book of Genesis. In the words of our Lord. “Had ye believed Moses, ye would have believed me: for he wrote of me. But if ye believe not his writings, how shall ye believe my words?” (*John 5: 46-47*).

Yours for Christ in Italy,

Rev. Frederick L. Whitman
Baptist Mid-Missions

PREFACE

Evolution and the origin of life. These are two closely connected subjects which all of us need to address.

In Italian schools the standard teaching on origins and the development of life is what is known as abiogenesis, or spontaneous generation. Darwinism is almost universally accepted as an undisputed and indisputable scientific fact. However, the more closely abiogenesis and evolution are examined, the more clearly does it emerge that they are nothing more than hypotheses which are upheld more for cultural than for scientific reasons.

In this book, Fernando De Angelis faces the problem of origins head on. Using concise and simple logic, he shows rationally and scientifically just how easily hypotheses can become accepted as *scientific truths*, even when they are built on very shaky foundations.

It is my sincere hope that this book will be widely read, by believers and unbelievers alike. The former will see that it is by no means a scientific obligation to believe in evolution, and that will strengthen their faith; the latter will be able to examine the subjects under consideration in greater depth, and in so doing they will discover the fragility of the theory of evolution as an explanation for the origin of life.

To close, let me borrow a quotation that is used later on in this book. That great scientist, Pasteur, who lived in the last century, affirmed as follows: «The greatest disorder of the mind is to believe in the existence of what we want to see». In its treatment of the origin of life, this book will help the reader to distinguish between the reality of the facts and the fantasies that have been built around them.

Paolo Veneziani
(respected Italian Evangelical leader)

THANKS FOR THE ENGLISH EDITION

I grew up believing that in Italy there were no other churches besides catholic ones. Instead, at 22 years of age, in 1968, in Perugia, as I was passing by an evangelical church meeting place, I discovered that this was not the case. When I entered that church for the first time, an Englishman, Peter Hedley, moved over on the pew to make room for me and teach me how to use the hymnbook. He couldn't speak Italian yet so we couldn't speak to one another, but his kindness impressed me.

At the end of the service, that for me had been a totally new experience, I asked for an explanation from the two elders of the church, Angelo Zolfaroli and Franco Ciuchi. Since they were busy, and seeing that I was a student, they introduced me to the "specialist" for students: Fred Terino, an American missionary of Italian origin. All three, however, opened wide the doors of their homes and I, who had need of humanitarian as well as spiritual help, took great advantage.

When I was invited to take the Bible seriously, I immediately objected because Darwin had demonstrated that it was not a wise thing to do. Fred, however, was evidently very well prepared from the various studies done by American creationists. He made me see that really, it was Darwin who shouldn't be taken too seriously. From that very moment, it seemed to me that the contrast between the two philosophies was irreconcilable. Soon Fred organized a conference with another American missionary, Thomas Heinze. I had read his Italian book against evolution while it was still just in mimeographed form. I remember that one of his statements, while at the dinner table, challenged me to look into the extra-scientific motivations behind the Darwinian theory.

Since I teach natural science to students between 14 and 19 years of age, I was forced to study evolution more and more but I did not feel sufficiently prepared to write a book on the subject. The encouragement of Ronald Diprose, a missionary from New Zeland, and now an Italian citizen, was a determining factor in the writing of this book. Ronald expressed faith in me and exhorted me to begin to write down my thoughts.

There was an urgency to write a book like this here in Italy because the concordist theory (which tries to reconcile the Bible and evolution) was not being challenged or opposed by any group and had already penetrated the thoughts of many who are considered fundamentalists. Sensing that the battle was too great for my single and weak efforts, I desired to enlist the help of others in the founding of an association that would carry on the battle in contrasting the world's culture (evolution among other philosophies). After having attended a conference by John C. Whitcomb in Italy in 1987, I found that my desires coincided with those of Frederick L. Whitman, an American missionary who had been here in Italy for many years. At this point we began to pray together and plan for an organized defence of biblical creationism in Italy. It is not by chance that, after all these years, Frederick has taken the responsibility to print this book.

At the beginning, when the association took its first baby steps, Dr. John Meyer, of American Institute for Creation Research (ICR, El Cajon, CA) offered to come to Italy. His time in Italy was very important and, besides the technical help, showed us a great example of seriousness and prudence in contrasting the distorted ideas that were circulating regarding the creationist movement across the ocean. We went to university professors as well as uneducated believers and John was always at ease.

The first edition of this book was printed in Italian by another American missionary, Bill Gust, and his wife Harriet, who had founded the printing house "Casa Biblica". Due to the counsel of their son Billy, who had grown up in Italy, and his appreciation for this manuscript (that a couple of evangelical editors had already read with disinterest and discarded) the decision was made to print this book.

It had been Leigh Pennington who introduced me to Bill. When he left Italy he left me with a great sense of loss, especially because of my conviction that his work among the churches throughout Italy was very useful. My sadness was partially alleviated by the fact that he, in returning to America, made the first translation and has encouraged the printing of this edition.

Englishman Michael Steedman, contacted and encouraged by my friend Paolo Veneziani, worked hard to review the first manuscript of translation, suggesting several valuable changes.

This book, therefore, can be seen as a "coming home" of thoughts that left from America and to America are returning, after having been applied to the Italian culture and adapted to its specific culture. The Latin context forces us to give attention, not only to the scientific problems, but also to the historical and cultural ones. I am pleased that this English edition can, in part, reach people of the French and Portuguese languages who have problems similar to those of the Italians. (A translation has been started in the Spanish language as well.)

I have dedicated this book to my wife. A very small token of appreciation toward the one who paid a tremendous price for remaining at my side in a life full of turbulence and battles not always won.

Behind the faces of those who were of help to me, I often saw, with clearness, the hand of God; present even when it was hidden from view. To Him, who 16 years ago extended to me the call of a particular responsibility in His work, I express my deepest gratitude. God's service, for me, has been like a rose: there have been plenty of flowers, but there have also been lots of thorns. Among the flowers, this English translation is one of the prettiest (especially for the time at which it has bloomed). Of the thorns, how could I complain with the One who bore them for me on the cross? My joy is in the fact that He is risen, lifting up with him those who have become one with Him *(Romans 6:5).*

Cortona (Arezzo, Italy), May 30, 1995

Fernando De Angelis

1. INTRODUCTION

A. CRITERIA ADOPTED

The contents of this book have been taken from teaching notes prepared for students and colleagues in high schools. The book has two basic aims:

1) to present as much as possible of the contents in language which will be easily understood;
2) to search for as much common ground as possible between the author (a biblical creationist) and his readership (who are presumed to be sympathetic towards Darwinism to a greater or lesser degree like most Italians).

There are a few places in the book where the first aim has not been fully achieved and where a specialized knowledge would be necessary. However, even those who lack such knowledge are unlikely to lose the thread of the argument, because the more difficult subjects are either preceded or followed by a simpler synthesis.

In order to achieve our second aim we have made extensive use of quotations. We have taken these not from evolutionists that we find easy to accommodate, but mainly from those who are most highly esteemed and qualified in their own fields (F. Crick, P. Omodeo, F. Dyson, J. Rostand, A. Hallam, G. Montalenti). The reader will thus be able to see for himself that certain statements we make are not derived from our own anti-Darwinian preconceptions but from an objective evaluation of the problems.

This book adopts an anti-evolutionist stance, but we have wanted to fight fairly. We are convinced - and this conviction has been strengthened by a number of readers of the teaching notes - that even in these difficult and often bitter disputes, it is possible to shake hands like gentlemen at the end. This is not because each side has compromised a little, but because both have respected the rules of the game and have fought against ideas rather than against individuals. They have recognized that no-one can claim superiority over another, because the defects we see in the next man are a reflection of those that we ourselves have, or easily could have.

If we were writing for a scientific journal we would abstain completely from non-scientific aspects of the subject. As it is, we are addressing ordinary readers who are being bombarded with information of various kinds and of varied reliability. They need to be provided with counter-information which deals with both the strictly scientific and the non-scientific aspects while not confusing the two.

Evolutionism is often presented as the definitive scientific answer which supersedes all other kinds of answer. However, Evolutionism as a whole lies on the outer fringes of science and it is open to debate whether and to what extent it is science at all. That is why we have felt it necessary to dedicate an entire chapter to pointing out what we understand by science and what role we wish to assign to it. We are convinced that the text of the Bible is still true today in every part. However, we are equally convinced that when we hold a dialogue with someone who does not share that conviction we must reason on the basis of a common language, a language that is not derived from the particular beliefs of either party. In this way, even those whose presuppositions differ from our own will be able to continue reading without being disturbed by one-sided arguments.

The notes have been grouped together at the end of the book. In order to spare the reader the inconvenience of having to refer to them frequently, we have chosen to

restrict ourselves almost exclusively those of a bibliographical nature. This means that unless the reader has a specific interest he can avoid consulting them altogether.

B. EVOLUTION: A PROBLEM THAT NEEDS DEFINING

The term "evolution" is often defined in different ways both at a popular and a scientific level. For the purpose of clarity we therefore need to state the meaning that we intend to give to this word and to others connected with it.

There are certainly numerous different aspects to the theory of evolution, but the oddest and most controversial of these is the assertion that the more complex species of animals and plants (dogs and oak trees, for example) come from other species that are very different and much simpler than they are themselves: the dog is supposed to have passed through many intermediate stages, having earlier been a type of fish. The specific name attached to this way of understanding evolution is *macro-evolution* (macro = large), to distinguish it from *micro-evolution* (micro = small). With macro-evolution there are changes in the structure and new organs are added, whereas with micro-evolution only small changes take place. These changes are generally quantitative; they do not alter the general structure of the creature, but only develop -to a greater or lesser extent - what is already there.

We find, for example, that there is enormous diversity among the various breeds of cats and dogs that exist, but despite the great differences between them in terms of size, fur, behaviour and certain specific abilities, the basic structure remains the same: a dog remains a dog and a cat remains a cat. Appearances notwithstanding, the differences between the various breeds are in fact small; at the very most we could describe these as examples of micro-evolution. On the other hand, the transformation of a land mammal (a cow, for example) into a sea mammal (like a whale), or of a mouse into a bat, would no longer be an example of micro-evolution but of macro-evolution.

Another very important distinction that needs to be made is that between *evolution* and *involution*. By evolution we mean the development from more simple to more complex. We will therefore not refer to the opposite phenomenon - namely the process of change from more complex to more simple - as evolution (although this is often done), but as involution. Evolution occurs if the descendants manifest functions and organs that were absent in their ancestors (for example, the development of wings in a species that has never had them before). Involution, on the other hand, occurs when the offspring lack some structure or function that was present in their parents (the birth of a dog that is blind due to a genetic mutation, for example).

It will be useful at this stage to summarize in outline form what has been said so far.

Involution: *loss* of organs and functions**.**

Evolution: *acquisition* of organs and functions.

- **Micro-evolution:** *small, quantitative* changes.
- **Macro-evolution:** *large, qualitative* changes.

Involution, that is, the birth of creatures with large or small defects, occurs continually before our eyes and there is no need to demonstrate it. Micro-evolution, that is, small quantitative changes like an increase in height, for example, is also an accepted phenomenon. It is with macro-evolution that problems arise; that is to say, with the appearance of organs and functions that are completely new. Someone might reply: «But by a process of small changes one arrives at large ones». That is to misunderstand the problem: micro-evolution involves the *development* of what is already there,

whereas macro-evolution involves the *appearance* of what was not there before. These two phenomena are quite clearly distinct, and **one cannot simply produce examples of micro-evolution (or, worse still, of involution) to demonstrate macro-evolution**. Supposing a new breed of sheep appeared with legs that were so much shorter than normal that it was not able to jump over fences; that would not be a case of macro-evolution but of involution. It is also involution when a normal fruit-fly gives birth to a fruit-fly with deformed wings or indeed without any wings at all. For this reason we point out that from now onwards, **when we speak of evolution we mean macro-evolution,** unless we specify otherwise.

When evolutionists assert that present species have developed by transformation from earlier forms, they do not generally face the problem of their very first appearance - in other words, the origin of life itself. Therefore, an evolutionist may either believe that it was God who created the first forms of life (whether simple or not so simple), which then evolved into the species we have today; or that it was the Earth itself which produced the first forms of life, starting with non-living matter that came together *by chance* (abiogenesis or spontaneous generation).

It is also necessary to distinguish between Evolutionism and Darwinism. Darwin suggested *one way* in which evolution could have occurred. Lamark suggested another, other modern writers have suggested still further ways. This means that even if Darwinism should prove to be completely false, it does not follow that evolutionism as a whole would collapse, because other evolutionary theories could take its place.

To summarize, we can ask ourselves three basic questions: 1) How did life originate? 2) In the course of history, have life forms undergone considerable modifications through evolution or not? 3) A question for the evolutionist: By what mechanism did creatures evolve?

These three questions can be answered in different ways, thus giving rise to different sets of responses. Here, too, it will be useful to produce an outline indicating the most radical answers to the above questions.

A. How did life originate?
A1. By means of *direct* creation by God (CREATIONISM)
A2. By the *chance* coming together of non-living matter (ABIOGENESIS OR SPONTANEOUS GENERATION)

B. Did the first life forms evolve?
B1. No, they remained substantially the same.(FIXISM)
B2. Yes, they became more complex. (EVOLUTIONISM)

C. How did they evolve?
C1. Lamark's theory.
C2. Darwin's theory.
C3. Other theories.

So the first problem which needs to be dealt with is that of the origin of life, and that is what we will be doing in this book.

C. SPONTANEOUS GENERATION: THE OLD WAY OF SAYING "ABIOGENESIS-EVOLUTION"

To believe in spontaneous generation means to believe that a creature can be generated spontaneously from nature without the need for parents of the same species. It is claimed that life can come from non-living matter, and that the moist earth is capable of "creating" certain inferior animals and plants. Spontaneous generation is an extreme form of evolutionism which combines two distinct concepts. These can be summarized as follows:

1) living things can come from non-living matter;

2) the living beings of one species can come from living beings of another species.

Darwin believed in both assertions, but was shrewd enough to concentrate on the second, which is less preposterous than the first, and to water it down by allowing an extremely long time span. That is how his theory was able to survive when, shortly after the publication of his foundational work, Pasteur proved that at least today all creatures derive from other creatures of the same species. In short, Darwinism is the life-boat that is trying to rescue spontaneous generation's second assertion, which is on the point of sinking. Another life-boat will try to rescue the first assertion under the new guise of *abiogenesis*. Giuseppe Montalenti acknowledges that «in modern biology the term *spontaneous generation* is out of favour: it can be replaced by *abiogenesis*». (G. Montalenti, *L'evoluzione*, ed. Einaudi, 1975, p. 207).

So it is that since spontaneous generation has become unpresentable in its original form, abiogenesis and Evolutionism have divided the spoils between them, reproposing it in new forms. This represents an attempt to render it unrecognisable and to conceal the enormous damage the theory has done to the progress of science.

Therefore, by dealing with the problem of the origin of life from a historical perspective, we will be casting light on the whole of Evolutionism and preparing the way for an examination of the work of Darwin. This is what we want to come on to as soon as possible.

Finally, while at the beginning there was a struggle between spontaneous generation (or abiogenesis) and **biogenesis (or creationism),** later on it was the duel between Evolutionism and Fixism (which considers the species to be fixed, unchangable entities) that was to continue the confrontation between the two basic tendencies.

Having rapidly set the scene in this chapter, we can now start to examine the subjects before us in greater detail.

2. THE HISTORY OF SPONTANEOUS GENERATION UP UNTIL PASTEUR

A. SPONTANEOUS GENERATION BEFORE REDI

It is easy for young children to believe in the most fantastic things, and it seems that we do not automatically lose this ability on reaching adulthood. You can find evidence for this by reading the description of an encounter between a Canadian journalist and an Eskimo by the name of Qaortok (1):

> «Qaortok took out of his pocket a strange wooden statuette which resembled a witch. He looked at it, stroked it and then whispered some incomprehensible words to it. “What is it ?” I asked him. “Is it one of your amulets ?” “Oh no!” he replied. “This is Pinga, the lady of the Caribous” ... “Many years ago”, he explained with conviction, “people suffered from hunger and were often forced to eat grass and mud. Then one day a wizard decided to dig a deep hole. Out of it came so many caribous that they covered the face of the whole Earth. But the incessant greed of the hunters forced them one day to take refuge in an underground tunnel which was guarded by a large *tuktuk* (caribou) whose antlers touched the clouds. Now to persuade these herds of caribous to come out of their hiding place, we have to plead with Pinga to be merciful”. (Pinga is the aged, deified woman who is thought by these people to hold sway over the animals on the earth.)
>
> It is by means of the childish tale of an underground refuge that some Eskimos even today try to explain the decline in the number of caribous and the famine which for some years has forced them to live off the canned meat and beans provided free by the Canadian government».

Even the great Aristotle (384-322 B.C.), who dominated philosophy and science for almost two thousand years fell for spontaneous generation. He «attributed to it not only the existence of many insects» ... «and worms, but also fish (eels) and amphibians, etc.» (2). He restricted this, however, to animals which he believed developed in mud by means of «metamorphosis» (3).

Strange as it may seem, worse was to follow. In the late Middle Ages there was a belief in the existence of «trees that were capable of producing fruit containing geese or lambs» (4). Even as late as 1662 Kircher, a Jesuit priest, «strove to come up with a recipe for producing every kind of animal artificially» (5).

Here is the one for producing flies from the corpses of their own species: «The dead flies are sprayed and soaked in honeyed water. They are then placed on a sheet of copper and exposed to the gentle heat of still warm ashes. Almost imperceptibly, minute worms will be born from these dead flies. Little by little wings will sprout from their backs and they will take on the appearance of tiny flies. As they gradually grow they will eventually turn into large and perfectly proportioned flies» (6).

Among Kircher's other recipes there were ones for producing scorpions, snakes and frogs (7). There were even those who held that mice could be born from a dirty shirt enclosed in a jar containing grains of wheat (8).

This all seems ridiculous to us today, but for a long time this was not the case.

B. FRANCESCO REDI: THE FIRST BIG BLOW TO THE CONCEPT OF SPONTANEOUS GENERATION

The first person in the world to rise up against this magical view of how animals come into being was an Italian from Arezzo: F. Redi (1626-1698). He struck such a blow against spontaneous generation that it forced supporters of the concept onto the defensive. This subject is so crucial to the study of the species that he has only one rival for the title of *father of modern biology*, that other tenacious opponent of spontaneous generation: Lazzaro Spallanzani (1729-99).

Redi demonstrated that if by using a close-meshed net one prevented the flies from depositing their eggs on the dead flesh, no worms were produced at all. He vigorously maintained that **living creatures only ever come from other living creatures (biogenesis).** He did still accept that maggots found in cherries may be produced by the cherries themselves (because the cherries have life in them), but all in all, by attacking the idea that living creatures are generated from non-living matter he went against all the fables and superstitions that we saw in the last chapter and which were widely believed both by ordinary people and scholars alike.

After Redi other biologists carried on the fight against spontaneous generation - men like Malpighi, Vallisneri and Réaumure - until in the end it was affirmed that living creatures are derived from other living creatures *of the same species.* Thus it was explained that the maggot in the cherry is generated by a fly which injects a small egg into the cherry itself; it was discovered that the maggot comes from the egg, which then changes into the same species of fly.

Redi against Kircher, the Jesuit priest; Redi against magic and superstition. Was Redi also going against the Bible? Many people are inclined to think he was, and given that in the debate on spontaneous generation and evolution reference is often made to holy scripture and religion, we need briefly to deal with these arguments, especially because they give rise to so many misunderstandings.

C. THE BIBLE: A BOOK AGAINST OBSCURANTISM

The Bible is considered by some to be a book that belongs to the Middle Ages. The fact is, though, that it began to be written at the dawn of time and was completed before the end of the first century A.D. So if anything, it is the book of antiquity rather than of the Middle Ages. During the Middle Ages (circa 476-1492 A.D.) it was more normal to follow stories than the Bible, and superstition was much more widespread than faith.

Although most Italians have a Bible in their homes, they don't generally read it, which means that they cannot distinguish between what the most widely read book in the world actually says and what down through the ages people have claimed that it says.

For many people the gravest fault of this book is that it was responsible for the persecution of Galileo. But a minimum amount of documentation will immediately show that Galileo's accusers were not so concerned to defend the letter of the Bible as to defend the philosophy, the theology and the social and religious hierarchy of the day. From Augustine (4th century) onwards the Roman Catholic church never had too much difficulty in interpreting the sacred text symbolically. After the Council of Trent (1545-1563) and up until the arrival of Pope John XXIII in 1958, the Bible was never accorded a position of central importance in Catholicism. This is because in their anti-Protestant polemics it was tradition and the function of the hierarchy which were given centre stage.

When Joshua said: «Sun, stand still» (*Joshua 10:12*) he was not giving a lesson in astronomy, he was in the midst of a battle, where he required particular light conditions

in order to secure a complete victory over his enemies. As the text points out, Joshua spoke those words «in the presence of all the people». Even today a teacher speaking in similar circumstances would say the same thing: «Sun, stand still». If he said «Earth, stand still» it would sound meaningless and ridiculous to anyone who heard him.

These days the Catholic church itself comments on the passage in question in a way that is very similar to how Galileo interpreted it (9). He asserted that the Bible teaches us «how to get to Heaven», and not «how the heavens work».

Therefore, since the real cause of the opposition to Galileo was not the Bible, we must be careful about depicting his accusers with the sacred book in their hands. But if we do choose to do so, we must make sure that we put the Bible in Galileo's hand too; he had first-hand knowledge of it, he esteemed and respected it, and it was from that book that he derived the strength to resist his opponents and go on the counter-attack. When accused of going against holy scripture he replied - to summarise in the words of P. Rossi - that «the decrees of Scripture are absolutely and unchangeably true; they can never err. Yet their interpreters can err, especially with respect to those propositions which are presented in a form which has been adapted to make them intelligible to the Jewish people» (10). Galileo was convinced that the Copernican teaching which he defended so vehemently agreed much more readily with the text of the Bible than the teaching of Ptolemy did (11). Thus, in stating his convictions, Galileo had no intention whatsoever of discrediting the Holy Scriptures. Moreover, the Copernican system was not set up to oppose the Bible; in actual fact Copernicus, who formulated it in a book which he dedicated to the pope, was himself a catholic priest.

One reason why we have sought to highlight Galileo's attitude to the Bible is that when we come to look at Redi, who was a follower of Galileo's method, we find the same respectful attitude towards the Scriptures. Redi knew them deeply, and like Galileo he used them to defend himself against attacks levelled against him by certain hostile and highly influential ecclesiastics. This is how Omodeo sums up the situation:

> «Galileo's troubles were not remote; a naturalist friend of Redi's had been imprisoned and then exiled by the Inquisition for having the temerity to maintain that Spanish vipers were poisonous, whereas it was a truth to be accepted by faith that this was no longer the case since they had been exorcized by a holy bishop.
>
> Redi set things straight, not by putting on the mantel of a theologian, but by reasoning as a humanist or, more accurately, as a philologist: He quoted from the holy scriptures, compared the various passages, refuted any potential opposing interpretations, and brought his sound knowledge of Hebrew and Arabic to bear; by so doing he made even his most contentious opponents feel too disheartened to do battle against his fortress-like position». Thus he achieved his success by taking his stand **«on the ground of the literal interpretation of the text itself»** (12).

Going back to the account in Genesis, Redi was convinced that the first living creatures were created by the God of the Bible and that from then on they are born only of the «seed» of other living creatures. He stated as follows, «After many observations carried out on many different occasions, I feel inclined to believe that after those first plants and animals which the Earth produced at the command of the sovereign and omnipotent Creator, never again has it produced any grass or tree or animal (be it perfect or imperfect) of its own accord. Everything which is born from it or which we see in it today comes entirely from the seed of the plants and animals themselves» (13).

There is one way of believing in God and in the Bible which fills the world with non-existent miracles and magic. Of the other ways of believing in God and the Bible there is one which contrasts with this: it makes the Bible believer very rational and scientific, because by limiting miraculous events to particular moments in history (like the

Creation of the world, the exodus of the Jews from Egypt, the coming of Christ, etc.) and to particular circumstances, the world is emptied of a great deal of superstition and confusion. Biblical miracles generally speaking take place within the boundaries of natural laws and appear as miracles primarily to the eyes of those who believe, reinforcing their awareness of reality and the rules that govern it. This is not like magic, which in seeking to substitute and superimpose itself on reality, tends to devalue it.

Take for example David's victory over Goliath in *1 Samuel 17*. From one point of view there is nothing extraordinary in this episode: David's confidence of victory is based on solid experience - «your servant has killed both the lion and the bear; this circumcised Philistine will be like one of them» (*v. 36*) - and he prepares himself rationally - «he took his staff in his hand, chose five smooth stones from the stream, put them in the pouch of his shepherd's bag, and with his sling in his hand, approached the Philistine» (*v. 40*).

In the Old Testament it is primarily through Moses that God works in a miraculous way. But equally, it is through this same man Moses that He reveals Himself fully as «The God of the Law», the Law to which He has freely bound Himself. In this He resembles a constitutional monarch more than an absolute one.

So it is law - in other words, rationality - rather than occasional miracles, which forms the stable basis for God's activity. This concept is difficult for the Moslem to grasp. For him God decides what He is going to do from one moment to the next, and so laws are only apparent, representing for the most part the habits of a God who is usually quite unpredictable.

In the New Testament, too, we find that the miracles are not supposed to devalue the laws that govern the world. The miracles themselves are subject to laws which are more or less explicit. This can be seen by examining the places in the gospels where the feeding of the 5,000 is described. A miracle does take place, but at the time it seems as if only the apostles see it. Anyway, the multiplication of the loaves is linked to particular circumstances which would make it hard for the miracle to be repeated. The following details are specified: 1) The crowd had gone without food for three days because of their desire to follow Jesus; 2) they were in danger of dying from exhaustion; 3) loaves were used which were available at the time; 4) since it was a desert place it was impossible to buy the bread they needed; 5) the leftover food was not to be wasted simply because there was someone there who could multiply it; rather, it was to be gathered and used, because that miracle was the exception rather than the norm (14).

To conclude, biblical faith does not degrade rationality, it elevates it. There are other biologists who, like Galileo and Redi, seem to have had a high opinion of the Bible: think of that devoted Protestant, Linneo, or of those abbots, Spallanzani and Mendel, or of Pasteur, or more generally of all those exponents of scientific creationism who for two centuries (from the end of the 17th until the end of the 19th) played their part in the great advances made in the natural sciences. It is to this movement that we must turn in the next section, so that we can clear up other misunderstandings and gain a better grasp of how the struggle against spontaneous generation developed.

D. THE BIRTH AND FUNCTION OF SCIENTIFIC AND HISTORICAL FIXIST CREATIONISM

There have always been men and women who have held the conviction that the world was created by God, but it is not about this imprecise form of creationism that we

wish to speak here. Neither will we speak about that form of creationism which is in harmony with spontaneous generation and evolution.

The creationism which we propose to deal with actually emerged in the 18th century and is "fixist": this means that it holds to the fixity of the species - having been created directly by God in the first six days of Creation, they can no longer be formed other than through reproduction by parents of the same species. «By the seventh day God had finished the work He had been doing; so on the seventh day He rested from all His work. And God blessed the seventh day and made it holy, because on it He rested from all the work of creating that He had done», declares the Bible (*Genesis 2:3*) after mentioning several times **a creation and reproduction «according to its kin»** *(Genesis 1:11,12,21,24, 25).*

Pope Gregory Magnus (540-604), can be considered a Fixist Creationist. In this he differed from Augustine (354-430) and many other *fathers* of the Church, who favoured a creation which then led on to the development of the species by evolution. Thomas Aquinas (1225-1274) was another man who preferred evolutionary creation (15).

Bearing in mind the strong influence of Augustine and Thomas Aquinas on western Christianity, it is not surprising that the Catholic Church has always looked upon Fixist Creationism with suspicion.

The Creationism of Gregory Magnus was based primarily on biblical and theological arguments, and so we need to add the term "scientific" to indicate that what we are discussing here also has a scientific basis. We intend to put forward and defend our convictions scientifically, using arguments and evidence taken exclusively (or predominantly) from the realm of science.

This form of Creationism (roughly from Redi to Mendel) we also call "historical" to distinguish it from the Creationism of today, which has characteristics of its own. Scientific and Historical Fixist Creationism is often called more briefly Fixist Creationism, or Scientific Creationism, or simply Creationism. Therefore, unless otherwise specified, **by Creationism we mean Scientific and Historical Fixist Creationism.**

When people who are not familiar with the subject hear the term "Creationism" used, they often think of something which is different or even the direct opposite of what the word really means. To demonstrate this, one only needs to consider that Creationism in its outline form was born with Redi (in about 1668), whereas many people place it back in antiquity and actually identify it with Redi's opponents. Other scientists after Redi were to contribute to the systematic development of creationism and to promote it to the stage where it became -with varying emphases - the point of reference for the finest biology of the period that followed. Malpighi, Vallisneri, Spallanzani, Linneo, Pasteur and Mendel all proceeded (admittedly each in his own way) with creationism as their general guiding principle. In fact, after they have demolished spontaneous generation their work (especially that of Linneo and Mendel) becomes a valid counter-attraction to Evolutionism.

Let the person who seeks to draw comparisons with Galileo and the Copernican system, as is often done, not commit the usual error of regarding Creationism as the old theory. Cattaneo, a naturalist of the last century, wrote saying that, «a belief in some form of Evolutionism has always been around and that the real novelty in the scientific field during the first half of the 18th century was the appearance of the fixist belief. There is nothing paradoxical about this assertion; he is just stating a very simple truth, albeit one which has long been neglected. In actual fact, the more people study the question of evolution and the more intently people search for the precursors of Darwin and Lamark, the more difficult it becomes to escape that conclusion» (16).

Elsewhere (17) Omodeo states pointedly: **«Creationism, which from today's perspective seems like an ancient, deep-rooted theological doctrine, was in fact**

formulated towards the end of the 17th century; it was then accepted by the Church's magisterial in about 1740, after half a century of suspicious investigations».

So that we can discern more clearly who stood on which side in the Creationism debate, we will again turn to Omodeo.

> «The thesis that the perfection of living creatures testifies to the divine power and intelligence of a Creator did not, at the end of the 17th century, represent» ... «a resigned concession to orthodoxy» ... «No sooner does someone add that this perfection derives from an act of divine intervention which created *una tantum (all in one go)* the natural order of which we are all witnesses to, then violent protests break out. In fact tradition, such as was hammered home by the Counter-Reformation, postulates a creation *per causas*, a creation in which God makes use of secondary causes to realise His purposes. On this point the magisterial of the Catholic Church, supported by the propaganda of the Jesuits, is precise and decisive. Among the reformed churches, however, the idea of a single creative intervention (*in actu*, as it was called at that time) finds much favour. It is true that this idea was first set out by a catholic philosopher (the abbot Malebranche), but this was done in agreement with the Lutheran Swammerdam and later received the lasting support of such devoted protestants as Derham, Bonnet, Linneo and Cuvier. Later on the catholic magisterial, too, abandoned the traditional position and aligned itself» ... «with the position held by the protestants» ... «But this was not to take place until about 1740» (18).

In the 18th century, Creationism was expressed as *pre-formism*; according to this position «all the bodies of animals and human beings that will be born up until the end of time are the direct result of the original creative act. To express it more clearly, all the females were created with all the unborn offspring of their own species inside them» (19). This concept ran contrary to epigenism, which saw in the development of the fertilized egg a kind of spontaneous generation. The limits of both these concepts appear obvious to us today, , but we must bear in mind that people then could hardly have imagined the existence of DNA, whose discovery as recently as 1953 resolved the whole question. However, Montalenti (20) maintains that generally speaking it was pre-formism more than anything else which was responsible for progress in biology and which was closest to reality.

Among those who promoted pre-formism were the *Jansenists* (21); that is to say, those Catholics who were closest to the Protestants. This is not surprising, because the idea was worked out jointly by a Catholic abbot (Malebranche) and a fervent Protestant (Swammerdam) (22). A very similar joint venture was later carried out by another Catholic abbot -Spallanzani. His intellectual friendship with Bonnet (who was described as «a Protestant and deeply religious») (23) was such that Tourdes could write, «it would be difficult to find two people in the whole history of science whose exchange of letters has been warmer, more lively or more sincere» (24).

Another great defender of Spallanzani was Voltaire, who «followed Spallanzani's work with particular interest» (25). In a letter to a friend he let fly at Spallanzani's great opponent, a Catholic priest called Needham, who believed in the spontaneous generation of microscopic life forms. «Would you believe it», wrote Voltaire, «an Irish Jesuit has ended up putting weapons in the hands of atheist philosophy by claiming that animals form themselves?» ... «It was necessary for Spallanzani, the best observer in Europe, to come along and demonstrate unequivocally that the experiments of that imbecile Needham were groundless» ... «Believe me, my dear Marquis, there is nothing good in atheism» (26).

Voltaire associates Needham with the Jesuits (even though he was not one), and in connection with this problem he notices a common line of thinking between the Jesuits and atheists. That fervent protestant Bonnet likewise «charged Buffon and Needham - both substantially vitalists - with materialistic atheism» (27). This Jesuit-atheist combination may seem very strange to us, but Voltaire's words turned out to be prophetic, because although at first it was the Jesuits who were the strongest supporters of spontaneous generation, later on it was the atheists. Moreover, two centuries later it was a Jesuit, Teilhard de Chardin (1881-1955), who opened the way for the acceptance of evolution by the catholic church. Could it be that historical "Jesuitism", with its extravagant exaltation of the pope, is a christianised form of atheism, a return to Roman emperor worship ? It would be worthwhile taking a serious look at this. We will see later (in ch.3/F/b) that Jesuits today acknowledge this possible slide by Catholics into "popolatry", but to dwell on this here would take us too far away from our present theme. It is well to notice, however, that the dispute is at least three-sided (Atheists, Creationists and Evolutionist clerics) and not simply two-sided (Atheists and Clerics). What is more, each side regards its opponents as being similar to each other.

To conclude,

> «for the naturalists of the 17th and 18th century, who were keen to introduce valid, rational elements into biology, it was essential to rid the field of the continual miraculous interventions of Providence and other entities which were thought at that time to have been delegated to carry on the work of the Creator. Such interventions were being persistently postulated by followers of the ancient traditions» ... «It should be added that it was also felt to be vitally important to eliminate from the interpretations of the biology of development» ... «the whole weird and wonderful bag of tricks introduced by the magical concepts of the Renaissance» ... **«Fixist creationism, which is usually thought today to be an ancient doctrinaire corpus constructed in the defence of orthodoxy, was actually worked out at the beginning of the 18th century to fulfil this liberating function»** ... «The people responsible for this undertaking were scholars from Protestant countries which had the advantage of being free from the burdensome legacy of the Inquisition and from the shackles of traditional philosophy which had already been confronted by Luther. So the idea of a *una tantum* (28) creative act which established once and for all the ordered universe of which we are eye-witnesses, was not accepted by the counter-reformation - the Jesuits in particular fought against it. The reasons for their stand were undoubtedly numerous and complex» (29).

To sum up, the upholders of creationism were the following: the best biologists of the time; the Protestants; that great follower of the Enlightenment, Voltaire; and that section of Catholicism - a minority at that time - who were open to the modern world. Among these Catholics particular mention should be made of the Jansenists, the historic opponents of the Jesuits and the promoters of a renewal akin to that of the Protestants. Though this renewal was not accepted at the time, in the long term it did produce deep, positive effects, especially through the Second Vatican Council (1962-65). This Council agreed to several of their proposals (at least to some extent). Some examples of this are: the giving of greater prominence to the Bible; stress on freedom of conscience; the principle that the Church should operate by means of persuasion rather than coercion; the use of the language of the people in the liturgy; stress on the need for conversion and recognition of a greater autonomy for political authorities. These changes have brought Catholic culture much closer to Protestant culture.

Both Mazzini and Cavour came from Jansenistic families, and Manzoni was converted in part as a result of his friendship with a priest with Jansenistic tendencies.

But what is most of interest to us in our study is that Pasteur gladly went back to that great scientist and Christian thinker, Pascal (30), who was also the most famous of the Jansenists.

On the other hand, most conspicuous among the opponents of Creationism were the Jesuits, together with that section of Catholicism which was most deeply involved in the Inquisition and in closing society to political and cultural renewal. These represented the opinion of the majority at that time.

The opponents of Copernicus and Galileo now became the opponents of Creationism. Thus, **it is fair to say that if we associate the historical creationism of the 18th and 19th centuries with obscurantism we not only commit an error, we actually turn history upside down.**

E. SPALLANZANI: AN INCOMPLETE VICTORY

We have already seen (in section B) that Spallanzani competes with Redi for the title of *father of modern biology*, and we also spoke about him in our last section. However, given the importance of his work, we need to consider him in more detail.

In the fight against spontaneous generation, Spallanzani (1729-99) comes between Redi (1626-98) and Pasteur (1822-95). In fact, Redi died at the end of the 17th century, Spallanzani at the end of the 18th, and Pasteur at the end of the 19th. But Spallanzani is situated between the other two not only chronologically but also because of the type of work which he carried out. Redi laid the groundwork for the elimination of the idea of spontaneous generation from the world of animals that are visible to the naked eye, whereas Spallanzani fought against the theory of spontaneous generation among microscopic life forms; although he did not succeed in eliminating it, he paved the way for Pasteur's final victory.

Redi's opponents felt that the arguments he put forward were only partially valid, and the struggle between the two schools of thought went on even after his death. The supporters of spontaneous generation shifted the discussion to microscopic life forms, which appeared in abundant numbers in infusions -water in which organic substances of different kinds have been allowed to steep). Bacteria, protozoa and various minute animals were observed in the infusions. In about 1750, the monk and scientist Needham (31), backed by the then esteemed Buffon, made this claim: «All these creatures can change into one another; that is to say, plants can *animalise* themselves and animals can *vegetalise* themselves. So the germ of a grain of wheat, if placed in water, will produce filaments which can be detached, isolated in an hour glass, and then they in turn will produce tiny animals. Similarly it is possible to see dead flies or cicadas generate fungi».

He believed that «in organic liquids - and, more generally, in every part of nature - there is a *productive or vegetative force* which is capable of creating animate beings». Most abiogenesists did not reach these extremes, but anyway «many naturalists believed in the spontaneous generation of microscopic beings» (32).

It was in the context of this strong revival of spontaneous generation that Spallanzani began his experimentation. At that time he was just thirty years old and virtually self-taught. In a matter of a few years he was to discover «more truths than all the Academies managed in half a century» (33). But it is not just the quantity of his discoveries that led one person to say: «It may be no exaggeration to see in him the founder of biology as we understand it today» (34). It was above all in the principles and methods he used that he revealed himself to be thoroughly modern.

Spallanzani played a unique part in proving that the origin of the functions peculiar to a particular creature (such as its digestion, fertilization, respiration, etc.) «is not to be found in any mysterious influence which is a property of life itself. In short, he worked

effectively to reduce living things to the purely *physic-chemical*, which is exactly the direction taken by modern biology whatever philosophical opinion may be held regarding nature itself and the origin of life. In this connection it could be said that this priest was the great founder of *anti-vitalist* biology» (35), biology which opposes the idea that in the functions of living things mysterious, immeasurable forces are at work.

In order to discover whether the tiny animals in the infusions really did emerge by spontaneous generation, Spallanzani boiled up some sealed glass containers with the infusions inside. In those which were left boiling for an hour no infusers were ever seen, and this led Spallanzani to reject spontaneous generation.

Needham objected that Spallanzani «subjected the infusions to excessive heat, and by *putting nature under torture* he had forced it to lie. According to Needham, the excessive boiling had produced two effects: on the one hand, it had destroyed the *prolific or vegetative force* of the substances infused; on the other it had contaminated the air in the bottle» ... «The time it takes to boil a hen's egg was all that was required to destroy all the germs - if there were any in the first place» (36).

These objections raised by Needham were not without foundation, and Spallanzani carried out further experiments to try to overcome them. In this he was partially successful, but neither of the two sides was able to produce evidence that was totally convincing. However, «despite obvious imperfections, Spallanzani's experiments were clear and ingenious, bearing in mind the age in which they were performed. It is undeniable that it was these very experiments which paved the way for the labours of the great Pasteur a century later. Pasteur was only too willing to render homage to the ingenuity and far-sightedness of the Italian» ... «he “arranged for a large portrait of Spallanzani to be hung above the fire-place in his dining-room, right opposite his own”» (37).

We do not know much about Spallanzani's particular world view. In his work «there is a striking absence of any direct or indirect reference either to the Christian concept of a God who rules over a universe which he has created and supplied with immutable laws - such as we find in the works of Vallisneri and Bonnet - or to that *supreme Being* which would clearly indicate the influence of the Enlightenment» ... «Strictly speaking, the odd rare mention of God and His omnipotence are to be found, especially in the works of his youth, but they are nothing more than formal expressions devoid of any real religious significance and far removed from the impassioned invocations of Bonnet» ... «This is not to suggest that Spallanzani was an unreligious or a-religious man: it simply underlines the fact that for him religion belonged to the private realm» (38). His private life was something he «guarded jealously» (39) - and successfully: even in his letters and unpublished notes!

However, some further idea of Spallanzani's general orientation can be gleaned from the following considerations by Carlo Castellani.

> «In many respects Spallanzani was too far ahead of his time for the scientists of his day to be able to understand him and follow his example. Perhaps this is the explanation for his deep isolation and especially for the fact that not one of his many pupils worked alongside him or proceeded along the pathway that he had opened up» ... «Spallanzani was probably considered to be a kind of odd man out in the fabric of the so-called *scientific* milieu of his times» ... «Lazzaro Spallanzani does not properly belong to the science of the 18th century but has every right to be associated with the Positivist 19th.
>
> It is certainly no mere accident that the first people to sense the meaning and importance of the research carried out by Spallanzani were in fact two men of the early 19th century. Nor was it by chance that they happened to be working in the

crossroads city of Geneva, the very place that Spallanzani had chosen as his constant reference point.

The truth is that Spallanzani's work and methodology, which went largely unnoticed in the 18th century, had silently lit the fuse for that real scientific revolution that was to explode in the century that followed; the most significant fruits of it were to emerge in Claude Bernard's *Introduction* and in the microbiology of Luis Pasteur» (40a).

It was Claude Bernard, by the way, who «contributed more than almost any other lover of physiology to the progress of that science. He did so not only by discovering many facts which are of fundamental importance, but also through the methodological and teaching direction which he imparted to physiology» ... «It is largely thanks to him that the experimental method was adopted in the study of clinical medicine and therapy» (40b). Naturally, he too was critical of evolutionism (41).

Thus the connection which Castellani draws between the Italian Spallanzani and the Frenchman Pasteur is linked with Switzerland, and in particular, Geneva, the city shaped with biblical rigour by Calvin in the mid-16th century and which from that time on was to send out economists and reformers into the whole world. No doubt the abbot Spallanzani found himself in agreement not so much with the theology as with the attitude of Geneva. This can be deduced not only from the deep and lasting friendship he enjoyed with Bonnet, but also from the equally deep affinity between himself and the Protestant pastor Senebier. But as Di Pietro observes, «Spallanzani did not allow himself to be drawn into any philosophical *(or, we would add, religious)* speculation; he disregarded any mention of it by Bonnet» or anyone else. Di Pietro ends his study with these words: «In conclusion, it can be said that Spallanzani's relationship with the Swiss scholars -in particular with Haller, Bonnet and Senebier - represent a significant foundation to Spallanzani's thought and deserves to be examined more thoroughly» (42). What we would particularly like to grasp more clearly is how the elevation of the Bible then led to better cultural and scientific understanding. But for the moment we must just be content to notice it in passing.

While in Italy, Catholicism was still intent on illuminating the world with the fires of the Inquisition, Spallanzani was making friends with the "heretics" of Geneva, so proving himself to be ahead of his times in religious as well as scientific terms. He was showing once again that **it is not Christianity as such which is obscurantist, but rather a particular distorted way of understanding Christianity.**

F. PASTEUR: THE APPARENT DEATH OF SPONTANEOUS GENERATION

Pasteur started out as a research chemist, and initially he examined the peculiar properties of certain substances (produced during fermentation) to deflect polarized light. The important discoveries he made in this sector led him to become interested in fermentations and to ask himself whether they were the work of micro-organisms or not. At that time the answer was thought to be no, but Pasteur proved that where fermentation took place microbes were present and multiplied.

So it was in this way that Pasteur came to face the question of the origin of microbes: were they the result of spontaneous generation or of the reproduction of the microbes themselves ? As we have seen, this was a long-standing problem, and in spite of the contributions of Spallanzani, the question was still open. Interest in the subject increased with the publication in 1859 of a book of 700 pages written by Pouchet in support of spontaneous generation. 1859 also saw the appearance of that widely acclaimed and voluminous book by Darwin (about 500 pages) - *The Origin of the Species*. Stimulated by the controversy aroused by Pouchet's book and in an attempt to

resolve the ancient problem, the Academy of Science offered a prize to anyone who within three years was able by following properly conducted experiments to throw light on the question of spontaneous generation.

Pasteur was advised not to tackle the subject, firstly because he was not a biologist, and secondly, because of the sheer difficulty of the centuries-old problem. Nevertheless, he did tackle it, and within just a few months, on February 6th, he was already able to report some important findings. Then, on June 3, 1861, he submitted his final memorandum to the Academy. With it he won the prize, but more importantly, he produced incontestable evidence to prove that micro-organisms derive only from other micro-organisms and not from spontaneous generation.

Pasteur's communication to the Academy (43) is brief, clear and still perfectly valid today; in other words, it is just the opposite of the voluminous works mentioned above - even Darwin's work can be seen today to be crammed full of scientifically incorrect evaluations. In his own work Pasteur opens with a chapter that traces the history of spontaneous generation. He then goes on to reveal the logical phases of his research and the experiments he carried out in order to arrive at the solution to the problem. By filtering the air and examining the dust that is deposited on the filter, Pasteur proves irrefutably that there is a profusion of micro-organisms in the air. Then, by means of the memorable experiment which we are about to describe in summary form, he demonstrates that it is these wandering germs that cause the various substances to ferment.

It was already known before Pasteur's experiments that when a liquid was boiled and then sealed, it did not ferment. But if it was subsequently brought into contact with the air, fermentation began and proceeded rapidly. What was it in the air which set this process in motion? It had to be something which heat destroyed, because if calcined air (that is, air which had been passed through red-hot tubes) was applied to the boiling liquid, then the fermentation did not begin. But one uncertainty remained: was it a particular chemical substance that caused fermentation, or was it the micro-organisms in the air? Naturally the biogenesists claimed it was the "germs" in the air, whereas the supporters of spontaneous generation maintained that the air functioned only as a stimulus to the organic substances, which grouped together to form micro-organisms.

Pasteur put some fermentable liquid in a flask with a long glass neck. Then he heated the neck until it softened, stretched it and turned the end upside down, so that it looked rather like the neck of a goose nibbling grass. While the liquid was boiling, steam emerged from the narrow neck, and then it was allowed to cool down slowly, gradually sucking air in from outside. The moisture in the tube trapped the solid particles and so prevented them from rising up it. When everything had cooled down and the neck was dry, other air entered much more slowly, replacing the air that was already inside. The solid particles suspended in the air were not drawn inside, because no air currents could be created in the long thin tube turned downwards that would otherwise have sucked them in.

This is how it was proved beyond any shadow of a doubt that it was the particles in suspension, surrounded by swarms of micro-organisms, that themselves set in motion the fermentations of sterilized liquids. This is because in their absence no fermentation had taken place.

Spontaneous generation had suffered another defeat, and after two centuries of continual struggle (from Redi to Pasteur) it could be considered dead and buried.

This spectacular success of Pasteur's paved the way for other more practical goals to be reached. In 1863 he began to study spoilage of beers, wines and vinegar, identifying the microbes that caused them. In 1865 he was asked by the Ministry of Agriculture to study a disease in silk-worms, pebrine. He successfully completed this study in 1871.

If microbes were responsible for spoilage in wines and diseases in silk-worms, it was natural to suppose that they also caused some diseases in animals and human beings. So it came about that Pasteur gradually became involved in the field of medicine.

Many women died in childbirth because of "puerperal fever". Pasteur vigorously reproposed an idea which had been circulated before without being accepted. «It is you doctors who carry the infection», he stated in 1873. «Wash your hands, wash your instruments in boiling water, expose the bandages to air heated to 130-150 degrees centigrade, and puerperal fever will not be transmitted any more» (44).

Then it was the turn of anthrax (a cattle disease which spreads to man, and cholera in chickens. Not only did Pasteur recognize the microbial nature of the disease, but also, by blessed good fortune, he discovered a revolutionary way of preventing diseases: vaccination.

After identifying, isolating and cultivating the cholera bacteria, Pasteur inoculated healthy chickens with it for the purposes of research. On one occasion, finding himself short of fresh preparations, he inoculated some hens with a preparation that was some weeks old and noticed that they did not contract the disease. The really strange thing was that they did not even contract it when later on they were inoculated with the fresh culture. From this a surprising principle emerged: a culture of old (weakened) microbes served to prevent the disease. Apart from chicken cholera, this principle was also successfully applied to anthrax, and so between 1877 and 1879 these two diseases were conquered too.

Given Pasteur's triumphs one could easily be led to believe that he went from glory to glory, but this was not always the case. «Few men of science have received as many honours in their lifetime as Pasteur did; honours, but also bitter disappointments» (45). In his defence of the truth, «more often than not he was on his own! Alone against tradition and conservatism, against preconceived ideas, and all too often against ill will» (46). «Envy, then, ambition, malice, ignorance and scepticism were unleashed at him by doctors and veterinarians, making life difficult for him in every imaginable way. At a certain point some of them decided they would have to force him to give a public demonstration so that they could unmask him once and for all. Such was their scheming that on April 28, 1881 the Agricultural Society of Melun sent Pasteur an *invitation*, which in actual fact amounted to a challenge. In this invitation Pasteur was told that the Society would place 60 sheep at his disposal» (47) on which the efficacy of his vaccine would be publicly tested.

Clearly Pasteur's opponents expected to win the challenge or else they would never have launched it in the first place. But was the evidence that Pasteur had been presenting over a period of time not clear enough? It certainly was, just as that of Copernicus, Galileo and Kepler had been. Why is it, then, that sometimes convincing evidence fails to convince? To answer that question here would take us away from our subject, but we intend to take it up later on. For now we will just take note of the fact that man is subject to an ideological disease which blinds him or makes him see double. It is like a fit of drunkenness which he only notices when it is past - if it passes at all. We would do well not to stand aloof from this, because we are all affected to some extent by such alterations in our eyesight and need to be extremely vigilant. According to a famous statement made by Spallanzani and Pasteur themselves, «the greatest disorder of the human spirit is to believe in the existence of things one wants to see» (48). It is a disorder which is hard to combat and one which the anti-creationists have suffered from to an abundant degree. Eleven years after Pasteur had proved that spontaneous generation does not exist -opposing among other things the 700-page book by Pouchet - an Englishman called H. Bastian wrote a book of more than 1,000 pages (49) in support of spontaneous generation. He maintained his conviction to the day of his death, which occurred in 1910. There were numerous others like him.

Darwin, for example, did even worse. As late as 1882, 21 years after the question had been resolved, he openly professed his support for spontaneous generation. He stated: «Although in my opinion no valid proof has emerged up to now in favour of the concept that living things develop from inorganic matter, I cannot help believing, in accordance with the laws of continuity, that one day this possibility will be proved» (50).

Even more sensational was the "Lysenko case", in which the chief protagonist was a Russian scientist of the same name who was under the protection of Stalin. At that time (almost a century after Pasteur had presented his evidence), about one and a half billion people spread throughout the world were obliged to believe the most incredible inanities. In Italy at that time at least a quarter of the population had complete trust in the daily newspaper *L'Unità* (a communist publication). In the edition of 25/6/1952 (page 3) the following statement appeared, «Before Lepescinskaia proved the opposite, it was held that a cell could only be born from another cell» ... «Lepescinskaia» ... «has discovered that cells - that is to say life itself - are also formed from substances that are not alive and have nothing to do with life». This choice of extreme evolutionism led to the firm claim that among the results obtained were the following: «500,000 vines around Moscow, cotton with natural colour, potatoes which do not go bad in the hot climate of Kazakhstan, orchards and vegetable gardens above the Arctic Circle» (51).

Spontaneous generation is an incredible seven-headed monster which regenerates itself and keeps appearing in new guises: later on we will deal with its present form - abiogenesis - but for now we will bring to a conclusion our study of Pasteur.

The French scientist's last great discovery was how to lessen the effects of a *microbe* which up until then it had not been possible either to isolate, or to see, or to make breed outside the living tissues it attacked. This *poison* (Latin: *virus*) was that of rabies, an atrocious disease transmitted to man by dogs and at that time practically incurable. Pasteur was obliged to test his vaccine on a young man called Joseph Meister, who had been bitten by a rabid dog. The experiment was a complete success, and far from suffering a horrible death, young Joseph was able to continue his life without even contracting the disease. The case hit the headlines and it was partly as a result of it that three years later the Pasteur Institute was opened, where it was possible to make great strides forward in the development of vaccinations and research into vaccinations. So it was that Pasteur ended his days surrounded with honours.

«All experimental research», claimed Pasteur (52), «must be guided by certain preconceived ideas». Pasteur did not generally display his own preconceived ideas in the context of his scientific activity, but we can discover them through other sources. For example, in a speech given on the occasion of his election to membership of the French Academy we read: «The Greeks have bequeathed to us one of the most beautiful words in our language, the word *enthusiasm* - *en theos* (53) - a god within. The greatness of human actions is measured by the inspiration which gives birth to them. Fortunate indeed is the one who carries within him a god, an ideal of beauty, and is true to it: an ideal of art, of the Homeland, of Gospel virtues. These are the living springs that produce great thoughts and great actions. And they are all illuminated by reflections of the infinite» (54).

Apart from these high ideals, Pasteur derived his direction and stimulus from the great scientists of the past. In the opening part of the speech cited above, Pasteur addressed the members of the Academy with these words, «Perhaps you are also grateful to me that in my research into this arduous problem of the origin of infinitely tiny beings, I adopted an experimental rigor which finally wore down all opposition. But let us give the credit to that strict application of the rules in the method handed down to us by those great experimenters: Galileo, Pascal, Newton and their disciples

over the past two centuries» (55). Evidently for him there were three outstanding examples to follow in experimental methodology: Galileo, Pascal and Newton. That means that the characteristics we find in these three scientists shed light for us on Pasteur too. We spoke about Galileo at the beginning. In regards to Pascal we should note straight away that not many people would count him among the best three scientists before Pasteur. The fact that Pasteur himself did so is highly significant. We said something about Pascal in the last section, describing him as the greatest of the Jansenists. He was a scientist-theologian: this is a characteristic which we also discovered in Galileo, though to a lesser degree. This quality was also very evident in Newton, who «was concerned [*with theology - ed. note*] from his youth, and such was his success that at the time when that great work *(the* Principia - *his fundamental work on astronomy - ed. note)* was published, he was regarded as an excellent theologian. Following the trend of the time, he produced a work, which was published posthumously in 1773, in which he expounded the prophecies of Daniel and Revelation with great erudition, attempting to apply them to the development of historical events» (56).

It is no surprise, then, to hear Pasteur described as «a man whose heart was constantly dominated by a strong religious faith» (57). This despite the fact that because he did not display his faith openly, it is rarely if ever mentioned in portrayals of him.

3. SCIENCE AND METAPHYSICS

A. HOW SCIENCE WORKS

The classic method of scientific research is considered to be the inductive method. If, for example, it is proved that some living beings are made up of cells, one can formulate the hypothesis that all living beings are made up of cells.

However, this theory could be disproved by the discovery of non-cellular organisms, and in fact the discovery of viruses has shown this to be the case, making it necessary to adapt the theory to this new piece of data.

Sometimes the deductive method is used instead of the inductive one. When this happens, the scientist formulates a hypothesis which goes beyond the data that has been collected up to that time. Then, by means of new experiments, data is sought which harmonises with the hypothesis. If convincing data is found, it is deduced that the hypothesis is valid. In other words, evidence does not always precede a theory, and it is not rare for a scientist to try to prove certain facts or prepare certain experiments on the basis of a theory arrived at by intuition. While it is true that sometimes seeing is believing, it is also true that at other times the validity of a certain hypothesis is believed in first and the actual truth of it is discovered later.

B. SCIENCE: BETWEEN OBJECTIVITY AND SUBJECTIVITY

It was also true of Galileo, who is considered to be the founder of scientific method, that theory often preceded the data.

> «Fact, for Galilean science, is only that which can be achieved on the basis of precise theoretical criteria. This means that the interpretation of experimental data may be made on the basis of predetermined theories. Any experimental results which disagree with them are interpreted as *disturbing circumstances*» ... «Torricelli, a follower of Galileo, is even more explicit on this point: “If ,then, balls of lead, of iron or of stone refuse to go in the expected direction” ... “we will just say that we are not going to mention them”» (1).

So data which contrasts with a theory sometimes cancels out that theory, but at other times it is the data that is cancelled and placed in the basket labelled "oddities", in the hope that it will be cleared up some time in the future.

We can see to what extent Galileo used this mechanism by the way he treated Kepler's work. Galileo was convinced that the only motion which did not require the continuous application of a force was a uniformly circular one. This was therefore the only motion he could conceive of for the movement of the planets around the sun. This raised a number of questions, and in order to try to resolve them , like the astronomers before him he resorted to various expedients, some of which were more convincing than others. After making careful calculations based on proven observations, Kepler established that all these stratagems could be eliminated by simply considering that the planets move around the sun in elliptical orbits rather than circular ones. As they were both Copernican, Kepler and Galileo knew and respected each other. Galileo learnt of Kepler's work at least 30 years before he died, but he had «no regard for Kepler's great

discoveries» (2), because they went against one of his strongly held preconceptions which he would not give up.

As we have seen, Spallanzani was highly acclaimed for the scientific quality of his method of research (ch.2/E), but he was prevented from discovering the function of spermatozoa by his conviction that living creatures are pre-formed in the unfertilised female egg. He expressed his desire for absolute objectivity in a publication on this very subject. In it he states that he wants to rid himself of every notion he has learned «and thus find myself», he says (3), «like a *tabula rasa (clean slate, ed. note)* in this research work. This will make me more open to receive the images that come to me through my visual sense without having to worry about other people's inventions». This just shows that despite their firm intention to be objective and let the facts speak for themselves, scientists can be unconsciously conditioned by prejudices which prevent them from seeing reality correctly.

Albert Einstein is reputed by some to be the greatest scientist who has ever lived. But not everyone knows that after revolutionizing physics he rejected the prevailing formulae that followed. This happened because of his own religious convictions more than for scientific reasons. In fact, he is known to have rejected the most widely accepted formula of the quantum theory because it perceives the atomic phenomena as originating by chance rather than from a particular law. For him (and others like him, including Popper) this was unacceptable in as much as he believed in a world that was ordered and governed by precise laws, because it had been created by a God who at times was complicated but never evil. To quote a famous phrase of his, this God «does not play dice».

Einstein was a Jew, and when he was 11 he often used to read the Bible (4), which profoundly affected him. Even though he was to arrive at a conception of God which was philosophical-ecumenical, there remained noticeable traces of the orderly God of the Bible. The religious perception which prevented him from accepting the prevailing interpretation of the quantum theory was the same as had given him the strength to make his great discoveries. In fact, in speaking of Kepler and Newton he stated: «Only someone who has devoted his own life to similar projects can form a true picture of what animated these men and what gave them the strength to remain faithful to their goal despite countless failures. It is cosmic religion which produces strength like that» (5). Elsewhere he says: «The most profound and sublime feeling we are capable of is the mystic experience. It is from this alone that true science is born. Anyone who does not know this feeling» ...«is already dead spiritually» ... «My religion consists in this: the humble worship of an infinite spiritual being of a superior nature who reveals himself in the small details which we are able to perceive with our weak, inadequate senses» ... «It is religion which has enabled mankind to progress in all fields». As regards evolutionism he expressed his opinion publicly in 1950, when he said, «I consider the evolutionist teachings of Darwin, Haeckel and Huxley to have perished without hope» (6).

Being conditioned by one's own presuppositions can lead not only to a failure to see what is there but at times even to seeing what is not there. Spallanzani's great opponent Needham (see ch.2/E) was one of the greatest scientists of the age and was the first Catholic to be admitted to the prestigious English academy, The Royal Society (7). He was amazed that Spallanzani had failed to prove spontaneous generation and said: «If, like me, he had seen those seeds» ... «if he had been able to observe that the head of every plant» ... «produces apparently lifeless seed-shaped globules which are formed before the observer's eyes; if in the end, after this spectacle, he had observed how these same globules that break out of the matrix en masse are really animated, running here and there» ... «then I am sure that his good faith and wisdom would have spared me the kind of reproof which he seems to be giving me» (8).

Another famous case is that of phlogiston. This was thought to be a very light substance which permeated metals, giving them the properties of lustre, conductivity, etc.. When these metals are subjected to high temperatures they lose the characteristic properties mentioned above, and this was attributed to the fact that the phlogiston was expelled. All the chemists of the day searched passionately for this phlogiston, making great progress in the field of chemistry in the process. The data seemed to show that it existed, everyone believed that it existed, but no-one could find it. Finally it was Lavoisier (1743-1794) who, by systematically introducing scales into the chemistry laboratory, showed that the changes produced in metals by high temperatures were not caused by the *loss* of phlogiston but by the *acquisition* of oxygen. Thereby it was proved that phlogiston did not exist.

Then there are times when someone sees double or deliberately deceives, setting up a chain reaction which spreads and perpetuates the error. It reaches a point where the observer is so deafened by persistent voices from different sides that he becomes convinced that this absurdity is a real fact. At the end of the 18th century, for example, «people believed in *jumarts*, the result of crossing a bull with a mare/she-ass, a donkey with a cow, a bull with a she-ass, etc.. This belief was based on statements made by Leger and Staw, and most of all by Bourgelat, who was the inspector-general of the veterinary schools of France. He assured Bonnet that he had owned a number of these hybrids» (9). These testimonies deceived the great and respectable biologist Reamur (10), and also Spallanzani, who wrote: «The recent and very reliable observations» ... «undoubtedly prove that from the mating of such very diverse quadrupeds that extraordinary species of animal called the Jumart was born» (11). Reamur was so convinced of it that he tried to cross a rabbit with a hen, and Spallanzani tried to mate dogs with cats, even by means of artificial insemination. Today we know that no results are produced by trying to cross animals of different species and that jumarts were merely a deception. But at that time they were taken seriously by the most capable and scrupulous scientists of the age.

Does this mean that science is unreliable? We do not mean to say that. We just want to remove from the adjective "scientific" that aura of absolute certainty that some people still attribute to it. Science can produce a kind of certainty, but it is indeed a scientific certainty and not an absolute one. Writing on this question, Montalenti remarks: «Nowadays, after many years of consideration and investigation in the field of epistemology, we know perfectly well how naive and vain it is to expect to be able to engage in the investigation of natural phenomena with a mind which is absolutely free of all preconceptions. We know that the researcher is conditioned by numerous factors which for the most part he is not entirely aware of» (12).

While maintaining that to worship science is unjustified, we want to emphasize equally strongly that it is just as dangerous to hold science in such disdain that we feel authorized to imagine the strangest things without being bound by any objective criteria. At least science can be said to be pervaded by objectivity to some extent. Tangible evidence for this can be found at international congresses in certain disciplines (e. g. genetics and medicine), where people from all races, nationalities, cultures and religions can understand each other and work together: this is because the scientist binds himself to universal methods which rise above subjectivism. International congresses on philosophy, where philosophers of every tendency can compare notes and build something together, simply do not exist. This clearly goes to prove that because science can achieve such things, it does possess a certain objectivity.

In conclusion, scientific knowledge can be defined as *intersubjective* (13), that is, somewhere between absolute subjectivity and absolute objectivity. The degree of subjectivity will vary from case to case, so it will be useful to examine some criteria which can help us to evaluate the trustworthiness of a particular scientific statement.

C. CRITERIA FOR DETERMINING THE RELIABILITY OF A SCIENTIFIC ASSERTION

a) The facts: maximum reliability

More reliable than anything else are the observed facts, although even here there can be errors due to human fallibility or to prejudices in the observer or sometimes to his deliberate intention to deceive. Scientists, too, may behave dishonestly, usually because they are trying to gain fame and glory by using easy shortcuts.

Given that theories are an interpretation of the facts, they are naturally more subject to error.

b) Agreements between scientists

It is very important to ascertain whether all scientists agree on a particular argument. Even when this is the case the theory may be wrong, but clearly the chances of it being right will be much greater.

If a scientist starts his exposition by saying, "most scientists agree," we need to be very careful, because in science (like in politics) prevailing opinions are formed which, by the use of subtle or not so subtle methods, tend to eliminate minorities.

One very telling illustration of this is the case of the theory of continental drift (14), which was formulated by Alfred Wegener (1880-1930) and gave rise to present day geology. To start with geologists listened to Wegener, his work was translated into many different languages, and «in 1922 Wegener was able to state that he did not know of a single geophysicist who disagreed with his hypothesis» (15). But after some time, «to express sympathy with the idea of continental drift meant to put your career on the line». «The worst moment was reached when supporters of the theory of continental drift were scornfully dismissed as maniacs». From the theory of continental drift there arose the present theory of plate tectonics. «The nature of the mechanism which moves the continents is unclear to this day, and yet the plate tectonic theory has been so cleverly asserted that anyone who rejects the fundamental principles behind it is usually treated as a reactionary» (16). M. Polanyi maintains that in science «there always has to be a prevailing opinion about the nature of things, against which the validity of all assertions has to be measured. Any observation that seems to contradict the established view of things is judged invalid from the start and laid aside in the hope that later on it will turn out to be false or irrelevant» (17).

If 90% of all scientists are agreed about a theory, then we might well feel encouraged to accept it. But if we consider the remaining 10% who stand up to the opposition and pressure of all the others, we have to ask ourselves where they find the strength to resist and what arguments they lean on. It seems almost as if the scarcer the opposition, the more interesting it becomes to examine their view.

c) The relationship between theory and the data on which it is based

Two other criteria for judging the reliability of scientific assertions can be derived from the relationship between a theory and the data supporting it.

There are some theories which are imposed on us, so to speak, by certain facts or experimental data. In other cases the opposite is true: the theory is formulated first, and then the data which supports it is identified afterwards. In both cases the theory may be right or wrong, but obviously a theory that is determined by facts is more reliable.

Then there are theories which are based on much data and little mental elaboration. Others theories, on the other hand, are based on just a few pieces of incontrovertible evidence; the theory is derived from this evidence with the help of presuppositions and various elaborations.

It is obvious that a theory which is based on a lot of data is more reliable and more likely to last than one which is the fruit of little data and much speculation.

d) The connection between scientific theory and religious, philosophical and political concepts

A scientific theory may be connected more or less to a particular philosophy or religious concept. Clearly, if it supports or contradicts a certain world view it may be proposed, defended or attacked more for non-scientific than for scientific motives - and neither of the two sides can claim to be above suspicion. If in contradicting Galileo the men behind the Inquisition were motivated by non-scientific considerations - the desire to defend a particular ideological and social system - in Galileo himself there was the opposite non-scientific desire to attack that ideological and social system. This is how Paolo Rossi puts it: «Galileo's adherence to the Copernican vision of the world went back to almost fifteen years before his astronomic discoveries. It was not founded on a hypothesis but on the acceptance of a new concept which could stand in opposition to the deductivism of the Aristotelian, overturn mental images and present itself as a gateway to new possibilities for knowledge» (18).

When scientific and non-scientific motives become intertwined and overlap, the debate can easily turn into a fight, with everyone virtually forced to take sides with one of the two opposing factions. Each participant tends to stop his ears and raise his voice, and in the brief argument that follows there is a tendency to jump from one problem to another. In the end nobody quite knows what they are arguing about.

So that we can have a clear sense of direction in these matters, including the ones we are dealing with at the moment, we will apply four norms:

1) Do not rely too readily on the quotations a person makes claiming they come from his opponent; examine the two theses using texts written by qualified exponents of the two views.

2) Make a clear distinction between scientific comparisons and non-scientific one. It is legitimate to compare the two theses philosophically, but if we want to examine them scientifically we must not take non-scientific arguments into account.

3) Right from the start we have to lay aside all scientific arguments which have no solid basis.

4) It is also necessary to distinguish data from its interpretation.

After completing this work of clarification, we can set about comparing what is really reliable in the two opposing theses and arrive at an overall evaluation with the greatest objectivity we are capable of. Everyone should be prepared to admit that the thesis of the opposing party is scientifically more probable, even if he then adheres to the other thesis on the basis of non-scientific considerations. **We must strive to separate out the various levels of judgment (religious, political, scientific, etc.) and not mix them together, while at the same time choosing which type of argument we wish to favour.**

In a sporting contest the fight may be hard, but we must always show fairness, honesty and respect towards our opponent; we must be chivalrous. At the end of the contest the athletes often shake hands: it is much rarer to see the opposing fans doing the same. What we need to see is this "athletic spirit" when it comes to a theory, with the considerable effort that involves. Often it is easier to discuss with the most skilled opponents than with someone who has not studied the problems in depth. The unskilled

opponent who pretends to be sure of himself often relies more on the strength of his voice than on the strength of his arguments. On the other hand, the person who has honestly examined and evaluated the opposite point of view is more likely to argue calmly.

e) Falsifiability in science

The criterion of reliability which we have left until last should more properly be called a criterion of scientific nes. This is what people have been claiming more and more of late, and in fact a broad debate has begun on the subject. It all revolves around this criterion of falsifiability and was introduced by the Austro-English philosopher Karl Popper.

According to Popper, science is not the sum of what has been verified (i.e. has become true) by experience. Rather it is a combination of what is simply corroborated (i.e. reinforced) by experience itself. Before it can be considered scientific, a theory must be based on certain facts, it must foresee others (have the power of prediction), and it must be able to be denied (proved false) by unforeseen and contrary data. Anything that cannot be proved false, i.e. contradicted, by some future hypothetical piece of data or experiment is not science.

Like almost everybody else these days, Hallam agrees that «there is no sure way of achieving certainty or eliminating the possibility of error» (19). In fact, when the data confirms a theory, one cannot say that it has become true, because some new piece of evidence could emerge to prove it wrong.

We would say that certainty is a gift of God, and since Popper is of Hebrew origin, perhaps in arriving at his concepts he was influenced by *the Bible.* In fact, according to his own conception of things, the scientist has something in common with a prophet, since both proclaim truths that are hidden to others and which they invite them to accept. The prophets in the Bible would evaluate the times partly on the basis of the sure data of the written revelation of those who preceded them. They then foretold what would happen if society were to behave in a particular way. How could a true prophet of God be recognized? The Bible indicates a way of catching a prophet out, but it does not indicate any system to show with formal and absolute certainty that a prophet was truly speaking in God's name. A prophet was recognized to be false if his predictions were not fulfilled *(Deut.18:20-22)*, but even when the predicted sign did take place he could still be a false prophet whom God was tolerating in order to test the faithfulness of His people *(Deut.13:1-3).* Some signs (or clues) were foretold to help people to recognize the Messiah, but there was no unequivocal test that would enable him to be identified with absolute certainty. Even John the Baptist, who had publicly pointed to Jesus as the Messiah (*John 1:19-34*) and had received clear signs to back it up, began at one stage to have serious doubts (*Matthew 11:2-6*) and to consider even those signs to be ambiguous.

To conclude, certainty is a personal conviction which is not dependent merely on objective data. Objective data has to be seen and sorted in some way by the individual before he can come to absolute certainty.

D. SCIENTIFIC KNOWLEDGE AND PHILOSOPHICAL-THEOLOGICAL KNOWLEDGE

As we have seen, scientific knowledge is based more or less directly on data and experiments, while non-scientific knowledge is less bound to these factors - it is represented chiefly by philosophy and theology. This is not to say that philosophy and

theology are completely unconnected to facts, but a part of what a philosopher or a religious person believes may depend only very indirectly on facts.

History, as we saw in the previous chapter, is situated half-way between science and philosophy, because although it is based on facts, an author is free to select some rather than others and then join them together according to his own particular point of view.

Philosophical-theological knowledge, which we will also call speculative knowledge, is essential to man everyone is a philosopher, at least to himself. This is because we all ask ourselves questions and need guidelines for our lives which go beyond what science can provide. Therefore, this speculative knowledge is not a kind of second rate knowledge; on the contrary, it has to do with life's most basic questions and is what determines the most concrete choices we make.

The actual verification of a scientific method can not be done using another scientific method which is yet to be verified itself.

It is possible to separate scientific knowledge from speculative knowledge conceptually, but both kinds of knowledge are present in every human being and influence one another. Pasteur describes a possible relationship between the two types of knowledge by quoting approvingly the view of someone whom he merely describes as «a psychologist with an outstanding mind» (20): «The most precious notions hidden in the mind of man are at the back of the stage, enshrouded in a dim light; it is around these confused, apparently disconnected ideas that our clear ideas revolve, spreading, developing, rising up. If we were cut off from this background activity, the exact sciences would lose the greatness which they draw from their secret relationships with each other; infinite truths of which we have only an inkling».

We saw in chapter 2/F that in conducting his scientific work Pasteur did not reveal openly the world vision from which his science was at least partly derived. We could wish that everyone shared this approach. **Profitable collaboration in the science laboratory is possible only if each person leaves aside his philosophical-theological knowledge.** However, since the two types of knowledge have invaded each other's territory to such a great extent, it will be necessary for us as we study the subjects we have set ourselves to look at both aspects, while keeping the two separate.

E. THE POSSIBILITY OF EXPERIMENTATION IN SCIENCE AND IN SPECULATIVE KNOWLEDGE COMPARED

People always say that science is experimental, whereas other things are not. But after listening to Giuseppe Sermonti in Assisi in 1982 I was stimulated to consider that theology has its own way of being experimental too. And who is to say that way is inferior ? The reflections in this section are the result of the development of that stimulus.

Science is called experimental because it uses data and experiments to back up its ideas. This data and these experiments have two basic characteristics: 1) they can be reproduced any number of times; 2) the description of the data is not subjective.

In modern science one sometimes comes across two other characteristics: 1) an experiment or a piece of data can only be concretely interpreted by a specialist (if a layman were present he would not understand what had happened); 2) presuppositions play a decisive role in the description and interpretation of the data. In this situation the data produced in evidence is looked at more thoroughly and is naturally less compelling than data which is separate from the presuppositions which it is meant to prove. We find one example of the close connection between data and presuppositions in atomic physics. Here one may quite properly write whole volumes about electrons, even though no-one has ever seen one.

Naturally one cannot experiment with speculative knowledge in the same way, but this does not mean it should be overlooked. It is impossible to measure the joy a person may experience by using physical instruments, nor can it be reproduced at will in a laboratory: and yet we have all experienced joy personally. Such an experience is subjective in quality, and different from a scientific experiment, but it is none the less a real experience. Moreover, the ordinary individual has a certain advantage because while he has never seen or understood certain scientific demonstrations, he has experienced joy in a very concrete way. His non-scientific experience may be more proven and concrete *for him* than a scientific experiment. Therefore there is nothing absurd in him wanting to take it into account.

And to show just how concrete a religious experience may be we repeat a sentence which Pasteur quoted approvingly from that great English physicist, Faraday: «The notion of God and respect for Him reach my spirit along paths which are just as sure as those which lead to truth in the realm of physics» (21). And Guiglielmo Marconi once stated: «I believe in the power of prayer. I believe in it not only as a catholic but also as a scientist» (22). People normally associate prayer more with the attitude of Francis of Assisi than with an inventor like Marconi. It should be added that Marconi was also a captain of industry and «the inventor of multinationals» (23). But as we might expect, Marconi was educated in an special way: his mother, who was a British protestant, «took her children aside each evening to read *the Bible*» (24), a book than should not be neglected.

F. NON-SPECIALISTS AND SCIENCE

a) Non-specialists should not be despised

The world of knowledge has been revolutionized by specialists and non-specialists alike. A specialist is someone who dedicates himself almost exclusively to a particular area of research after having followed a normal course of studies and research. He has the advantage of being thoroughly acquainted with his subject, but he has the disadvantage of being conditioned by the prejudices and approaches of the past.

The non-specialist is generally self-taught and has not done a normal course of studies in that particular discipline, because often he is interested in other sectors too. The non-specialist is less likely to be prejudiced by the prevailing current of thought, and therefore when it comes to exploring new avenues he may have an advantage over the specialist. This is true also because his vision of the problem is often broader, embracing different disciplines. To use an analogy, a beautiful flower may cause us to forget the horizon.

Pasteur was a chemist, and yet he revolutionized biology and medicine. Boyle, the founder of modern chemistry, was a non-specialist. Wegener, whom we spoke about earlier (in ch.3/C/b) was esteemed at the end of his life principally «as an arctic explorer and a pioneer in meteorology, whereas of course today he is recognized more as the most authoritative proponent of the continental drift, even though he admitted himself that for most of his life this was little more than a marginal interest for him» (25a). Einstein was essentially self-taught, and when he revolutionized physics he was an illustrious unknown. «All of the great scientists», according to Popper, «were non-specialists» (25b).

We have absolutely no intention of eulogizing ignorance; it is obvious that specialists are responsible for great progress in science. We simply want to point out that the mere fact that observations come from non-specialists does not mean they are wrong. And we are not saying this just to lend validity to the arguments of the present author (who is a non-specialist) but mainly so that no-one will feel he has to approach science with an

attitude of helplessness. Everyone has to take responsibility for his own choices without acting by proxy for anyone else. This is something we will look at right away.

b) The danger of sacerdotalism in science

A great stir was caused by an article which appeared in *Civiltà Cattolica*, the Italian Jesuit magazine issued more or less directly by the Vatican. In it Catholics were exhorted to beware of the disease of infallibility. The influential *father* G. De Rosa later sanctioned and elucidated the article on Vatican Radio. The disease of infallibility consists in exaggerating the doctrine of papal infallibility out of all proportion until, according to *Civiltà Cattolica*, one reaches the point of «servility» and «popolatry» (26).

Instead of considering the pope to be infallible only in the extremely special circumstances indicated by official teaching -circumstances which have not occurred during the reigns of the last four popes - there is a tendency to attribute infallibility to him almost all the time. According to De Rosa: «The area of infallibility is very restricted. In fact he is infallible only when he speaks *ex cathedra*, i.e. as supreme teacher of the church, and intends to define a truth concerning faith and morals» ... «The last pope to do so was Pius XII in 1950» (27). The catholic who has contracted the disease of infallibility surrenders his own responsibility and relinquishes the privilege of having the last word on most of the decisions that have to be made. For him Christian freedom and individual responsibility are burdens which he feels unwilling or unable to carry. He tries to rid himself of them by means of blind obedience even to those who do not demand such obedience.

De Rosa continues: «The disease of infallibility is common in the Catholic world» (28). However, those who are not Catholic must not imagine that they are immune from this disease. Dostoevskij has written some disturbing pages about people's fear of freedom. He imagines a return of Christ towards the end of the 16th century, and puts some scorching words in the mouth of the *Grand Inquisitor*, who is terrified to think that freedom may once again be preached.

The Grand Inquisitor says to Christ, whom he accuses of preaching freedom: «There is no more troublesome or more tormenting concern for a man who has just become free than to find as soon as possible someone to kneel in front of». «Nothing has ever been more unbearable for man and human society than freedom». «So why», he cries, «have you come to trouble us?» ... «tomorrow I will condemn you and burn you at the stake». «For fifteen centuries we have been tormented with this freedom, but now it is over, over for good» (29).

Thank God, the Grand Inquisitor's plan did not work out. On the contrary, that was the very period in which the stage was set for freedom to flourish once more. In fact, the damage and cracks that were produced in various defensive walls were such that it seemed likely to gradually pervade the whole world. Nevertheless, freedom is always under threat in different ways.

Those who fear freedom do not only turn to Catholicism for false security, but often to political parties too (i.e. «if I sign up with that party all my problems will be solved») or to hierarchical religious sects. The United States is a country which places great emphasis on the freedom of the individual. It is no accident that it is the United States which has spawned a number of sects which openly or not so openly call for total submission from their followers, while offering them protection and security. Many of these sects have then spread to other lands. The main founding fathers of the United States were puritans. At that time this great freedom of the individual was balanced by an equal submission to *the Bible.* But when this point of reference is missing, freedom becomes more difficult to manage.

Even science may become a refuge from freedom. When this happens it becomes the object of a kind of worship. In Galileo's day science affirmed that the earth revolved around the motionless sun. In so doing it departed from the dictates of common sense, or rather it clashed with them. This was the most significant change (30). From that time onwards non-experts have been less and less welcome in science laboratories. They are only allowed in if invited by a scientist or some other qualified expert, and then only to view something put on specially for the occasion. Only the experts are allowed access to the real knowledge. Galileo tried again to make himself understood by everyone; Newton, on the other hand, declined, realizing that his theories could not be popularised; as for Einstein's scientific writings, they are understandable only to very few in their original form.

This detachment of science from common sense does not necessarily lead to its elevation to the status of a religion, but it certainly facilitates it. And when science is thus elevated it is no longer science but *Scientism*. Scientism can be defined as «a scientific movement which emerged in connection with French positivism in the second half of the 19th century. It tends to attribute to the physical and experimental sciences and the methods employed in them the ability to solve all man's problems and satisfy all his needs» (Devoto-Oli Dictionary).

The follower of Scientism considers science to be infallible. One look at the sacred vestment (in this case the white coat) is enough to satisfy him, making him feel as if he is participating in some mysterious ritual. He regards the laboratory as a kind of magic room where from one moment to the next the scientist/alchemist/magician will produce the philosopher's stone and the elixir for long life with which he will resolve all the world's ills. All he needs to do is to wait, cheer and applaud, i.e. be a spectator. And as we can see from the development of passion for sport and the growing addiction to television, man settles easily into this role.

Those followers of Scientism who are also real scientists will try to satisfy ordinary followers of Scientism (whom we have described above). They will not limit their pronouncements to their own fields of study, which is as far as science will allow them to express themselves with a certain objectivity; rather, they will tend to go beyond that, setting themselves up - like priests - as experts on life. When Galileo's science came into conflict for the first time with the clergy, it was a sign that it found itself (albeit justifiably) in the same territory as they were. And if on certain occasions it was the priest who suppressed the findings of the laboratory so as to increase the size of his church, on other occasions it was the scientist who tried to suppress the church so as to enlarge his own kingdom.

The conduct of Pasteur in this connection seems to us to be exemplary. While he denied spontaneous generation, he did not want to express any other hypothesis because he considered the problem of the origin of life to be outside the competence of science. This is how he expressed himself: «Rabies is never spontaneous, either in dogs or in other animals. All purported cases of spontaneous rabies have proved to lack any serious claims to authenticity; I would add that it is meaningless to argue that there must have been a first case of rabies. To use this kind of argument to solve the difficulty we are faced with means to raise pointlessly the still unfathomable problem of the origin of life. Scientists know that it is pointless to use science to argue about origins: they know that at least for now it is beyond the power of science to investigate the origin of things» (31). Elsewhere he states: **«Experimental science is essentially positive, in the sense that in its concepts it never introduces the question of the essence of things, the origin of the world or its destiny»** (32). Spallanzani acted along the same lines, something which, to our mind, every honest scientist should do, at least when he speaks as a scientist.

It is impossible to draw a clear distinction between science and religion, and it is only natural that there should be a certain friction between them. However, it is necessary to recognize the limits of one's own field and to respect not only one's fellow priest but also the layman who is caught up in the battle and who, to safeguard his own lay position, needs to have the strength to defend himself against attacks from different directions.

A layman needs to believe that *anyone* can understand the fundamental questions of life. Some may argue that this conviction is not rational: we agree that it is not a product of reason, but we do not agree that it is contrary to reason. Anyway, if the reader has no faith in his own ability to understand, if he considers that the statements made by Nobel prize winners and the television are to be accepted by him unquestioningly, then he might as well throw this book away. We intend to call into question some of the things which the official scientific world asserts with confidence, and it is essential that our readers be prepared to think these fundamental problems through personally, because they relate to the life-affecting choices each of us needs to make.

4. THE PROBLEM OF THE ORIGIN OF LIFE

A. THE MOST WIDESPREAD OPINION

The hypothesis that we are going to expound in this chapter is not the only one proposed by the scientific world, but it is far and away the most widespread and widely accepted one. Furthermore, in the numerous school textbooks I have come across, it is the only hypothesis presented and it can be said to go hand in hand with Darwinism: this is why we will concentrate our attention and criticism on it. This opinion about the origin of life is not generally given a specific name, but so as to bring out its most salient features we will call it *abiogenesis from primordial soup*.

The way in which it is usually described and the faith that is normally placed in it by science books have seen to it that many people (including many teachers) no longer consider it as a hypothesis but as a virtually proven reality. For this reason we will need to expound it objectively to see to what extent it is based on experimental evidence, to what extent it is still mere hypothesis, and to what extent it clashes with the scientific evidence already available.

After doing this scientific groundwork we will move on in the next chapter to some cultural aspects that are connected with the theory itself.

The four statements listed below constitute the foundational elements of abiogenesis from primordial soup (which from now on we will simply refer to as abiogenesis).The remainder of this chapter will be dedicated to a critical examination of these statements.

Statement no. 1. When it began to cool down, the atmosphere of primitive Earth was different from now : to be precise it was rich in hydrogen (H_2), water (H_2O), methane (CH_4) and ammonia (NH_3),while molecular oxygen (O_2) was totally absent, or almost so.

Statement no. 2. Lightning discharges during storms, solar rays and other such phenomena caused the formation of various organic compounds including amino acids (the building blocks of cells).These organic compounds were carried by rain and washed into the oceans, where they accumulated; this was possible because there was no free oxygen (O_2) present to destroy them.

Statement no. 3. Among all the molecules that formed in this so-called "primordial soup" there were some that were similar, if not actually identical, to proteins, nucleic acids and the other substances which go to make up the cells that exist today.

Statement no. 4. In certain places there was a chance meeting and joining together of the right molecules - the ones suitable for forming the first cell, a cell that was more simple than the one we know today. According to evolution, it was from this first cell that other cells similar to those of today were derived, and then those cells gave rise to all life forms.

Some supporters of abiogenesis confidently set out the various phases of the process (1). Others alternate between expressions like «ours is only a hypothesis» and contrasting ones which suggest that they are more or less certain; this puzzles the attentive reader, who finds it difficult to summarize the views of these authors (2). Others still are sympathetic towards abiogenesis but present the facts honestly and consistently, openly stating the unresolved problems and limitations of the theory. F. Crick, who is one of the two discoverers of DNA and who won the Nobel prize in 1962, belongs to this category of honest scientists who are able to distinguish between

experimental data and their own interpretative and philosophical opinions. In his book entitled *The Origin of Life* (3) he shows himself to be very balanced, in spite of what he writes at the end of the book (pages 149-153). There he sets aside scientific language and gives expression to his cultural inclinations, setting abiogenesis against the background of a world vision from which we feel we must dissent completely.

Dyson (4) is another person who, in spite of some expressions of exaggerated optimism, reveals clearly the great limitations of abiogenesis, even though he is a staunch supporter of the theory. In *chapter XIII* of his work entitled *L'evoluzione* (5), which deals with the origin of life, G. Montalenti, too, is balanced in his presentation.

When it comes to defining the claims of science we find ourselves substantially in agreement with Crick, even though we hold to two contrasting cultural positions and support hypotheses which are diametrically opposed to each other. And it is our hope that we can also reach agreement with many others who occupy cultural positions different from our own.

Although Crick has his own particular view on the origin of life, his approach remains substantially that of the abiogenesists which we have already presented. In fact, in the final analysis he agrees that life on earth may have originated from primordial soup. However, he considers it more probable that the process took place on another planet first. From this planet intelligent and highly evolved beings then sent off germs which then fertilized the primordial soup on earth. He prefers to move the phenomenon elsewhere, but he agrees one hundred per cent with the four fundamental affirmations of abiogenesis.

There is no shortage of people who on hearing our anti-evolutionist arguments will consider us, to say the least, to be blinded by our own non-scientific prejudices. To these people we heartily recommend the book by Crick (and also the one by Dyson): when it is seen how these two authors expose the limitations of abiogenesis it will be difficult to level the same accusations against them that are sometimes levelled at us.

B. THE PRIMITIVE ATMOSPHERE

Below a height of 10,000 metres the composition of the atmosphere today is virtually constant, being made up of nitrogen (about 78% of dry air) and oxygen (about 21% of dry air). The quantity of water vapour varies, and although it is very important, the percentage of carbon dioxide is low (0.03%). This atmosphere cannot produce the carbon-based organic compounds necessary for living things. And even if a small quantity were to form, the presence of oxygen would consume them by a process similar to that which takes place in a stove, only more slowly.

This means that anyone who believes in abiogenesis must presuppose that the composition of the atmosphere was different from today; that it was rich in hydrogen, methane and ammonia and almost devoid of oxygen. But is the existence of a primitive atmosphere like that a presupposition or a proven fact ?

This is how Crick expresses it: «At one time people thought that the primordial atmosphere of the Earth was very different from today. Since hydrogen is far and away the most plentiful element in the atmosphere, it was natural to believe that it predominated in the original atmosphere» ... «However, of late these ideas have been questioned. Hydrogen is so light that the Earth's gravity is insufficient to hold it down and, so it tends to escape into space» ... «It is now plausible to think that most of the hydrogen that was present at the beginning escaped so rapidly that it was never a predominant element in the atmosphere» ... «Today it is asserted, on the basis of experimental data obtained taking an average hydrogen content of *all* the rocks available of a certain age, that in the past the atmosphere was not very different from today» (6).

What we still do not know is what the atmosphere was like before the formation of the oldest known rocks. Crick remarks: «It is difficult to arrive at reliable conclusions on this question. Even the temperature of the primordial Earth is uncertain» (7).

So it emerges that it is not the composition of the early atmosphere which leads to the belief that abiogenesis really could have taken place; rather it is the belief in abiogenesis that leads to the supposition that the early atmosphere was of a particular kind. The expounders of abiogenesis often fail to clarify this point; they bring as evidence what is really a presupposition, one which is not only unproven but which actually conflicts with the data so far available.

C. THE COMPLEXITY OF THE CELL AND ITS COMPONENT PARTS

a) The cell: its unimaginable complexity

Those who describe the spontaneous formation of cells, which are the simplest life forms, often fail to explain clearly their extreme complexity and the fact that the simplest life form is the most complicated mechanism known to man.

It could be claimed that viruses are simpler living beings than cells, but they can survive only inside the cell; outside it they are incapable of performing any function. It is therefore in the cell that the phenomenon we call life takes place.

Some cells (bacteria and blue-green algae) are described as "simpler", because they lack certain structures, but these cells perform the same functions as those that are described as "more complex", and with the same chemical processes. In fact, as a whole bacteria are able to do many things which other beings cannot do: they live in boiling water, in ice, in oil wells, in nuclear reactors (i.e. in the presence of deadly radio-activity); they can synthesize organic substances by exploiting various chemical reactions (e.g. by burning sulphur); they produce vitamins, etc.. So there is no such thing as a "simple cell". Like a machine, either a cell exists in its entirety or it does not exist at all.

It is difficult to describe the complexity of a cell, because man has never constructed anything comparable. The construction of the best equipped chemical laboratory is like the ability to form a few simple letters in comparison with what a cell can create: one only needs to think of photosynthesis. The greatest human construction undertaking is a total mess created by a bunch of incompetent fools compared with what a cell can do: just think that by receiving nutriment and nothing else from outside itself it can construct an entire organism; in fact, a dog, an oak tree and a flower all originated from a specific cell which formed them by means of purely internal organization. The performance of the largest electronic brain is child's play compared with the human brain, which is also derived from a cell. And what machine is able to construct another machine the same as itself, in other words to reproduce itself as a cell does? So the cell's complexity exceeds anything we can imagine.

If we compare the work done by a cell with what takes place on a building site, the cell can be said to do the work of an architect, because it contains within itself (in the nuclear DNA) all the instructions necessary to fulfil the various functions. But it also works as a foreman, because it contains mechanisms capable of seeing to it that the right operations are carried out at the right moment (by means of RNA and various systems which regulate the work). Lastly, it is also a worker, carrying out the various tasks mostly by using proteins: nails, hair and muscles are just three examples of tissues made of such substances. Proteins and DNA are the two extremes of cellular organization and it will be helpful to look at these in detail.

b) The complexity of proteins

Proteins are made up of 20 different amino acids which are joined together to form long chains. The simple bacteria called "Escherichia coli" contains about 2,500 different types (8). Bearing in mind that on average proteins are made up of 500 amino acids, if we were to write down on paper those contained in "Escherichia" assigning to the 20 types of amino acids 20 different letters of the alphabet, we would end up with a composition 3 times the length of Dante's *Divine Comedy* (9), which is about six times the size of this book, or longer than the New Testament.

For their part, the amino acids which go to make up proteins are composed of 4 types of atom: carbon, hydrogen, oxygen and nitrogen; some also contain sulphur and phosphorous. These are produced by living things or in laboratories but they do not take shape on their own. If we wanted to compose them starting with atoms we would need a minimum of 10 (for the amino acid glycine) to a maximum of 27 (for tryptophane). Naturally they would need to be in the correct proportions (5 hydrogens, 2 carbons and 1 nitrogen for glycine) and correctly arranged. If we combine the atoms which make up glycine in anything but the prescribed way we do not get glycine but something different: it is like jumbling the letters of a word. Take for example the word "triangle": it does not have the same meaning as its anagrams "integral" or "relating", and most letter combinations would have no meaning at all (e.g. "iglarent", etc.)

If after composing the amino acids we wanted to proceed with the proteins we would need to perform a task similar to that of a typographer when he is setting the pages of a book.

To sum up, to manufacture a protein in a laboratory we would need to take the **correct** atoms and connect them in the **correct** way, making the whole series of 20 amino acids first. We would then need to take the **correct** amino acids and join them together **correctly**. (All this work would be impossible to perform in a laboratory without the direction of organic compounds produced by the cells.) After completing it, we would need to keep the delicate structure in the **correct** conditions -the right temperature, acidity, salinity, etc. - so that it would not be irreparably damaged. These five necessary correct choices highlight the obstacles that have to be overcome in order to make and preserve one simple protein. If we want to stay within a scientific framework these obstacles cannot simply be surmounted by asserting that somewhere, somehow, ages ago, the cell proteins we have today were formed and preserved.

c) The complexity of DNA

If we wanted to construct DNA, the first grouping we would need to make would be that of the four nitrogenized bases, which are often simply identified as A (adenine), T (thymine), C (cytosine) and G (guanine). To make each of these four bases we would need to take thirty or so atoms of four different types (i.e. carbon, hydrogen, oxygen and nitrogen) and combine them in the right way. Then we would have to prepare a special sugar, deoxyribose, (composed of 5 atoms of carbon, 10 of hydrogen and 4 of oxygen arranged in a fixed order), and phosphoric acid (phosphate).

These three starting compounds would then need to be fitted together in the right way so as to obtain the 4 nucleotides that correspond to the 4 starting bases (adenine-nucleotide, thymine-nucleotide, cytosine-nucleotide and guanine-nucleotide).

Finally the 4 nucleotides would have to be arranged in twos (adenine-nucleotide with guanine-nucleotide and cytosine-nucleotide with guanine-nucleotide) and these pairs would then need to be positioned one on top of the other to form a sort of ladder.

In order to give some idea of the difficulties encountered when one tries to make the necessary reactions for the formation of DNA happen by chance, we will consider the composition of a nucleotide starting with its constituent parts (nitrogen base,

deoxyribose and phosphate). The abiogenesist Dyson expresses himself as follows: «If the bonds form by chance, only one in a hundred molecules will be well structured from a stereo-chemical point of view. However, it is difficult to imagine a natural process capable of fishing out that one correctly formed nucleotide from among its ninety-nine defective brothers! Besides, sound nucleotides are unstable in a watery solution and tend to split into their component parts again» (10).

In a bacteria cell the DNA is made up of several million pairs of nucleotides (11), whereas they amount to a few billion in every human cell (12). (Generally speaking, both the quality and quantity of DNA in all the cells in an organism are the same). As we have compared the proteins in a cell to "The Divine Comedy", it would be legitimate to compare DNA, made up as it is of many more elements, to an encyclopaedia.

While proteins consist of a language of 20 letters, DNA consists of a sort of Morse code, but with 4 signs. It is the task of another kind of compound (RNA) to translate this language of 4 signs into the language of 20 signs - in other words, to make proteins on the basis of the instructions received from the DNA. But the way this is done is too complex for us to deal with here.

D. ELECTRIC DISCHARGES AS CONSTRUCTORS OF MOLECULES

In 1953 Miller exposed a mixture of hydrogen, water, methane and ammonia to electric discharges for a week. He obtained «a mixture of small organic compounds, among which there was a reasonable quantity of two simple amino-acids which are present in all proteins - glycine and alanine» (13).

It is not unusual for people to refer to Miller's experiment saying that in it *amino acids* are formed (and not *two simple* amino acids), «which constitute the constituent elements of proteins, the basic components of living material» (14). This way of explaining things fails to take into account either the obstacles that need to be overcome before the amino acids can unite to form proteins (see the previous section) or the infinitely greater obstacles to be overcome before the passage from proteins to cells can take place - we will look at these later. The reader is left with the deceptive impression that life has been reproduced in a laboratory, or almost! Therefore, let us examine the limitations of Miller's experiment in detail.

As we saw previously, it is *assumed* that the atmosphere present in Miller's apparatus was similar to the primitive atmosphere, but this has not been proved at all. On the primordial Earth the hydrogen «is supposed to have dispersed in space, whereas in Miller's experiment, which took place in an isolated system, once a molecule of hydrogen was formed it could not escape from the system and so the molecules gradually accumulated as the experiment proceeded» (15).

The fact that it was the two simplest amino acids which formed and not the other 18 - although these others are present in all living things - could also go to show that this path is not going to lead us very far. Imagine that I give a small child a pen, some sheets of paper, a pair of scissors and some glue. If amongst all the scribbles I manage to make out two letters of the alphabet, I cannot exclaim that by continuing to write haphazardly and by cutting and pasting he may produce a novel or a scientific treatise. Similarly, Miller's experiment proves precious little.

But then, even if by means of other experiments a more effective system were to be found for producing amino acids by chance, there would still be other problems to resolve. For example, apart from the 20 amino acids that go to make up proteins there are another 150 which are not proteins. If these were mixed in with the others it would create another almost insurmountable obstacle to the formation of the right proteins. It would be like trying to put together a book in Italian by taking the letters of the alphabet at random out of a bag containing 7 other different alphabets!

But the problems do not finish there. All amino acids, except for the simplest one (glycine), are asymmetrical. They are rather like hands in this respect: hands are made up of the same elements, but the individual parts (the fingers) are arranged differently, so that the left hand does not fit into a right-hand glove, and vice-versa. One hand can be said to be the mirror image of the other. Amino acids come in two forms, too - "L" (laevorotatory) and "D" (dextrorotatary) - and when they form randomly outside cells, half will be of one type and half of the other. In contrast, «every basic molecule in every organism faces the same way». This uniformity is amazing, because it is «arbitrary and complete at the same time» (16). In other words, in living things the compounds could be facing both ways or there could be some living things with compounds facing one way and others with them facing the other way. (This is what we would expect if they were formed by chance.) But what we find is that the compounds in a living thing all face one way only. To be specific, «all the amino acids in proteins» ... «are of the L series» (17), and glucose «is in the same dextrogyrate direction everywhere in nature» (16).

For anyone who does not believe in it, these difficulties demonstrate that abiogenesis cannot be proved. For those who do, however, Miller's experiments prove that life originated from a single primordial cell which formed by chance and then transmitted the same pattern to all living things. Abiogenesists recognize that a cell is unlikely to be formed spontaneously, but, they say, difficult does not mean statistical impossibility. We will therefore have to take a short look at statistics.

E. BEWARE OF THE DECEPTIVENESS OF STATISTICS

So as not to make our discussion too heavy, we will start with an allegory. A judge had to pass sentence on one of the chief directors of the football pools, who was accused of fraud. A relative of his had hit the jackpot ten times in a row by betting with a single two-column coupon at a time. Was it fraud or just luck ?

The defence counsel had roared: «You can't condemn someone when you know that however unlikely it may be it is possible to win the jackpot ten times in a row». To lend greater weight to his argument he had called a professor of statistics with whom he began to discuss publicly. «Professor, is it possible to hit the jackpot twice running?» The professor replied before the judge: «Yes, it is possible». «Is it possible to hit the jackpot five time running?» «Yes, it is possible». Finally the defence counsel came to the crucial question: «Professor, is it possible to hit the jackpot 10 times running?» The professor replied again: «Yes, it is possible». Finally, turning to the judge with a look of satisfaction, the lawyer said: «We should at least give the accused the benefit of the doubt; and as we all know, in cases of uncertainty we are duty bound to acquit».

The judge was somewhat perplexed; his common sense told him that the accused was guilty, but those statistics had bemused him. After reflecting for a while he summoned the professor again and asked him: *«What is the likelihood* that a person filling in just two columns will hit the jackpot 10 times in a row?» The professor replied: «It is as if you had an ocean full of marbles, all of which were white except for 10, which were black. Then a person who was blindfolded came along and picked out all the black ones». But the judge was still not satisfied, and losing his temper asked: «So according to statistics, when could one be certain that there was a swindle? After 100 consecutive jackpots? Or 1000? Or 10,000?» Smiling benignly, the professor replied: «Never, your honour. You can never be certain». The judge was getting more and more irritated. «How do *you* decide in cases like this one? Do I take it, then, that even finger prints are inconclusive?» «Well», replied the professor in conclusion, «generally we fix a limit of probability. Anything beyond that limit we consider to be certain. It is obvious that if we did not act in that way we could never take any decision and even finger prints

would not constitute a final proof». The judge returned home in a thoughtful mood. Should he condemn the accused or resign?

We have used this illustration because everyone has to reach a similar verdict on the question of the origin of life by abiogenesis and we must be careful not to be taken in by unclear statistical arguments. **Anyone wishing to use the argument of possibility should also quantify the degree of probability there is of a certain phenomenon taking place.** Otherwise it is like placing the correct forecast of the result of one football match on the same level as hitting the jackpot a thousand times in a row: logically both are *possible*.

Therefore, every time an appeal is made to the argument of possibility we will try to make some calculations to see how probable it is that the phenomenon will occur. Since the figures involved in these calculations are very high exponents we should give some examples to make these figures more meaningful.

If someone offered you 60 cheques one at a time, each to the value of $2,000,000, asking you in return for 2^1 (=2) beans for the first cheque, 2^2 (=4) beans for the second, 2^3 (=8) beans for the third and so on up to 2^{60} beans for the sixtieth cheque, would you agree to it ? Of course, you could not stop after the first few cheques. The calculation is not very complicated (see appendix 1), but the result will surprise you. The sixtieth cheque would cost you more than 2,500 billion hundredweight of beans at a value of more than a million billion dollars!

So be careful of numbers with a high exponent; you can read them quickly, but they represent unimaginable figures.

Another example will help to clarify other aspects of the problem. If I flip a coin it will come up either heads (H) or tails (T). If I flip it 100 times there is no way of telling how many times it will come up H. All we can say is that on average it will come up H once every two flips, or 50 times every 100. If we flip it twice there is a one in four chance that it will come up H-H, because there are four possible combinations (H-H, H-T, T-H, T-T).

Now let us move on to a more demanding illustration: let us consider the difficulty a monkey would have in typing a given sentence by hitting the keys of a type-writer at random. We will choose the sentence, *evolution is the best*, which contains 21 letters. To make the task easier, we will say that instead of the normal 50-odd keys our type-writer has only 20, containing all the characters that we need.

Nobody can tell how many times the monkey will have to strike the keyboard before he manages to type the sentence, but we can work out the number of times on average. As we begin our calculations it soon becomes obvious that this is too much work for one monkey, so we will employ a billion. But even then this is lengthy work, because on average they will need to hammer away at their type-writers for 10 billion years. After all that time only one of them will have managed to type the sentence *evolution is the best*.

One might imagine that it is not all that difficult to produce a bit of order by chance, but when one starts calculating it becomes apparent just how difficult it is. Unfortunately authors do not always make this point clear, and not many readers know how to do the necessary sums or take the trouble to do them. As a result they are fatally deceived.

F. FROM AMINO ACIDS TO PROTEINS: MORE DIFFICULT STATISTICS

We have already spoken about some considerable difficulties we would encounter if we wanted to form proteins by chance, but in order to look at other important aspects we will ask the following question: «What volume of wrong proteins would I need to make before I came up with a specific one by chance?» It would be rather like saying:

«If I have a pile of beads of 20 different colours and I want to make up a particular necklace by putting them together at random, how many incorrect necklaces will I have, on average, before I come up with the one I want?» We have chosen an extremely simple protein made up of only 100 amino acids; nevertheless, the figures involved are astonishing. (See appendix 3).

The protein in question would be in such a large cube of incorrect proteins that it would be hard to imagine. One side of it would be 10^{32} Kilometres long. If we wanted to cross that cube in search of our protein in a rocket that went round the Earth more than seven times a second (i.e. travelling at the speed of light), it would take us 10 billion billion years! In this immense cube the whole galaxy (which is only 100,000 light years along its longest side) would look like a small dot.

The strongest telescopes explore the universe up to a distance of 5 billion light years: this is insignificant compared with the cube of proteins that would be necessary, on average, to form a specific one from among the simplest types by chance. Crick makes similar calculations (18), with comparable results.

A teacher of chemistry has remarked that to try to form a particular protein it is not necessary to have such a large quantity of amino acids, because it is possible to dismantle an incorrect protein and try again with the same material. But if we introduce this concept, it becomes even more difficult to form a protein made up of 100 amino acids, because if we increase the number of amino acids that are joined together it becomes more and more probable that the chain will break rather than get longer. And when we finally arrived at our longed for protein it would not survive anyway - it would break up straight away.

The difficulties that we have been examining should have shown how difficult it is to create order out of chaos. However, Oparin, the founder of the Soviet school of abiogenesis, confidently asserts that «the primordial organic substances evolved, undergoing further changes and transformations. Hypotheses can be made about the processes involved in these transformations on the basis of experiments carried out in the laboratory (S. L. Miller, M. Calvin, C. Ponnamperuma). There it is possible to reproduce the environmental conditions that would exist on the surface of and inside a lifeless Earth. The results show that under these conditions numerous organic substances are formed. Some of these substances are very complex and some are even compounds characteristic of living cells; for example, there are substances similar to proteins and nucleic acids» (19). However, unlike his admirer and follower Dyson, he fails to point out that so far complex and ordered substances have only been obtained when an organizing template has been present which is extracted from living things.

Taking the most recent discoveries into account, Dyson explains as follows (20): «Eigen has produced DNA without the aid of a code. Orgel has achieved the same result without an enzyme but using a code (in living cells RNA is produced with codes and enzymes together). If we suppose that RNA was the original molecule of life, that means we must produce RNA without using either codes or enzymes. Neither Eigen nor Orgel have managed to come anywhere this goal».

And if a scientist then managed to fabricate not only a protein but even a cell, using his own intelligence and capacity of choice, what would he prove? That life is the result of a work of intelligence and programming. He would certainly not prove that it is the product of chance.

Anyone wishing to explore the statistical difficulties involved in the formation of proteins and cells, and in evolution in general, can consult the excellent and clear work by Thomas Heinze (21). The lectures he gave at Perugia in 1970, if I recall correctly, provided me with an excellent stimulus for further reflection.

G. FROM PROTEINS TO CELLS: AN AWESOME STEP

Let us suppose that in the primordial soup, by some inconceivable piece of good fortune, there developed - in addition to numerous other similar substances - those that go to make up a cell. Even that would not lead easily to the emergence of the first cell.

Let us take an example. If I have all the pieces of different types of clock in the same bag, I am unlikely to pick out the right ones to make a particular clock by chance. It would be no easy task to find the right pieces among so many others, some of which looked very similar, and then fit them together in the right way. Cells are made up of thousands of strictly coordinated substances; if those to be fitted together are spread among an infinite number of other substances similar to themselves it is hard to imagine all the right ones - and only the right ones -coming together by chance. And even if they did all come together, we still would not have arrived at a cell. In fact, if we mince up some living cells, we will have all the substances needed to construct those cells, but they will not re-form themselves, because the various parts do not have the tendency to recombine spontaneously.

Besides, we have to presuppose that in the hypothetical primordial soup there are many poisonous substances, which even in small concentrations can prevent life occurring; so even if a cell had formed, it could not have survived.

The supporters of abiogenesis bear these objections in mind, but even the most well-informed and balanced among them take measures to remedy matters by speaking about an event which is statistically improbable but which by a particularly fortunate combination of circumstances took place anyway. Commenting on the situation, F. Prattico (22) says that following the experiments by Miller (see section D),

> «a great shout of triumph went up from the researchers around the world», but then, «after the initial enthusiasm had passed, doubts and criticisms began to be voiced in the scientific community. For example, many researchers now claim to be convinced on the basis of geological evidence that the primordial atmosphere was not like the one created by Urey and Miller in their alembic; others even contest the concept of *primordial soup*, claiming that conditions like those would only have produced tar. But the most logical criticism is a mathematical one: the few hundred million years which separate the formation of the Earth from the appearance of blue algae would be insufficient, according to the law of large numbers, to bring together *by chance* the sequence of amino-acids necessary to produce an enzyme, an active protein».

Prattico proceeds with his argument: «A typical enzyme is composed of a sequence of about 200 amino-acids structured in a highly elaborate fashion. The chances of obtaining a sequence like this by chance is 10^{120} (a figure with an indescribable number of zeros, while to obtain a protein would require 10^{40000} random attempts! The whole life of the universe would not suffice to produce such an incredibly long series. So the *mystery thriller* of life deepens. Only a particularly fortunate coincidence, a practically unique happening, could have brought into being the first self-reproducing molecule».

Crick expresses himself in a similar fashion. «An honest man, armed with all the available knowledge, can for now only assert that given the great number of conditions that needed to be met before the mechanism could be set in motion, the origin of life appears to be almost a miracle» (23). Crick's wife is convinced that when her husband talks about the origin of life «he's not really dealing with a theory but with science fiction» (24): and we can only agree with her.

In expounding a suggested updating of Oparin's ideas, Dyson admits that from our own formulations «sometimes we will derive illuminating indicators about the real

world; it is more often the case that the model is nothing but a plaything for those of us who have a craze for mathematics» (25). The television personality Piero Angela, who is a great publicizer of evolution theories, reviewed Dyson's book sympathetically. In his review he summarized the present state of the research on the subject we are dealing with, saying: "Much has been written on the origins of life, but as yet little has been understood» (26).

When there is talk of «a practically unique event» (Prattico), «almost a miracle» (Crick), «a plaything» (Dyson), we are no longer (or not yet) in the realm of science. Scientists can occupy their time talking about what might be possible, but if they do they are not involved in science but in speculation.

This is what Dyson writes on the last page of his book: «The conclusion of my story brings me back to the beginning. Guided by my own philosophy, I have sought to imagine a framework for the origin of life. What I have found is an abstract mathematical model which is too simple to be true. Consistent with my philosophical leanings, I am inclined to believe that such a description is applicable to all evolution of life from its origins onwards» (27).

Whether one declares it openly like Dyson, or whether it is simply implied, behind abiogenesis there always lies «a personal philosophy» and a particular world view. It is on this extra-scientific plain that we need to continue our discussion, but we will keep this separate, leaving it for our last chapter.

5. FREE REFLECTIONS ON ABIOGENESIS

A. ABIOGENESIS: MORE METAPHYSICAL THAN SCIENTIFIC

In 1861 Pasteur demonstrated that *here and now* spontaneous generation does not exist. Since Pasteur's time supporters of the concept have had to retreat and say: «Not now, but some time in the far distant past, yes». Moving back billions of years, it seemed almost impossible to contradict them. But now even Crick realizes that we are reaching the stage when it might no longer be possible to maintain that life on Earth began billions of years ago by abiogenesis. That is why another escape route has been invented, namely that life emerged on an unknown planet in outer space. «If not here», Crick would say to Pasteur, «it would be possible elsewhere», thus making it more and more problematical either to prove it or to deny it. These are his words: «If one day we arrive at the conclusion that it (spontaneous generation) is extremely improbable, then we will be forced to take into consideration the possibility what might have happened in other parts of the universe where perhaps for one reason or another the conditions were more favourable» (1).

The belief in spontaneous generation has always been based on evidence which has turned out to be flimsy. But the collapse of the evidence has never led to the final demise of that concept; it has always reappeared in a different guise. Abiogenesis is also accepted whether the evidence that is supposed to prove it is valid or not.

This is how Montalenti puts it, «It is extremely improbable that living things of a complexity similar to that of bacteria, were formed suddenly in the past from inorganic matter. Bacteria are not as simple as used to be thought. Their structure is extremely complex consisting of membrane, of nuclear and cytoplasm matter, and of various inclusions. The idea that they were formed by the direct aggregation of molecules seems infinitely improbable to us» ... «however, even when faced with these negative results, many biologists refused to jettison the concept and continued to consider spontaneous generation as a theoretical possibility as they waited for it to be proved. In fact, the origin of life on Earth has to be explained somehow, and spontaneous generation is one possible explanation» (2).

Dyson is even more to the point, and in a certain sense disturbing, when he says: **«For fifty years Oparin's theory seemed to biologists to be the only alternative to biblical creationism, and for one reason only: not because there was evidence in its favour, but because it enjoyed almost unanimous acceptance in the scientific world»** (3).

The God of the Bible arouses in most people a sense of unease which they seek to dispel by imagining that somewhere or other, at some time or other, somehow or other, life began by itself. This attitude reminds us of the words that were shouted out against the prophets of old: «Leave this way, get off this path, and stop confronting us with the Holy One of Israel» (*Isaiah 30:11*). Everything seems to be acceptable as long as it neutralizes *the Bible*, but that has little to do with science.

B. WHAT IS AT STAKE ?

The way in which the problem of the origin of life is tackled and resolved will naturally determine the way in which the problem of the origin of the various species is tackled and resolved - including the origin of man.

Therefore, it is not a question which has only to do with biology; it has wider implications which are cultural, philosophical and religious. The history textbooks in schools begin by dealing with abiogenesis, evolution and hominoids. When they start to talk about man they have already consciously or unconsciously presented a framework within which everything else they deal with will be placed.

If in the beginning man was a mere animal - uncouth, brutish and with little intelligence - we are forced to admit that he has made considerable progress and we are liable to expect that probably he will go on improving. Vice versa, if one accepts that humanity has descended from Adam the situation changes completely. Adam was created in the image of God; he spoke to Him and was in perfect harmony with Him. Compared with Adam, modern man appears to be in progressive decline.

According to Benedetto Croce, to begin the history of mankind on the assumption that his origins were «bestial and mechanical» means «to create pseudo-history in two senses: it is false history in a general sense and it is false history of nature». In the opinion of Croce, the most influential Italian man of culture this century, «this does not revive the intellect, it mortifies the soul» (4).

Moreover, if the first book of the Bible is taken literally it is only natural to do the same with the last, the Book of Revelation, or the Apocalypse. At the end of that book the Apostle John exclaims: «Come Lord Jesus!» (*Rev.22:17-21*). But how many people would join in chorus with the apostle? For the large majority of people the very name *Apocalypse* is synonymous with dreadful catastrophes and the judgment of a God with whom they want to have no dealings. Abiogenesis serves very well to remove Him from our horizon.

Just a few years after Pasteur had finally demonstrated the groundlessness of spontaneous generation, in his own country the authoritative Larousse dictionary made the following declaration: «Spontaneous genesis is no longer a hypothesis, it has become a philosophical necessity. It alone is rational, it alone frees us once and for all from puerile cosmogonies and sends back into the wings that external and totally artificial *deus ex machina (God the creator, ed. note)* who has been ignorantly worshipped for centuries» (5).

Monod associates himself with this line of thinking (6), as do many others within Italian cultural circles, constantly associating God and the Bible with the worst phenomena. We maintain that the reason for this is that in the past in France, as well as in Italy, many people have acted in the name of God and the Bible in trying to perpetuate injustice, to keep the people in ignorance, and to suppress knowledge. But in those place where in the name of God and the Bible the values of democracy, liberty, justice and progress have been promoted (e.g. in Switzerland, the United States and England), the attitude is generally different.

Martin Luther King, the great leader of black emancipation, was a Baptist pastor. This is no coincidence, because in the struggles of former days as well as today in the United States

> «the Baptist Church» ... «has played a crucial role. During the times of slavery religion was the only source of comfort for people who were bought and sold like merchandise and who were denied everything, including the right to marry» ... «But according to Rev. Joseph Roberts, the present pastor of Ebenezer Church, the Church also became important as a symbol and substitute for the civilized society which the blacks were excluded from: “For us it was everything - school, chamber of

commerce, Lions club, hospital, the place to go to if you can't pay the rent and are about to be thrown out of your home"» (7).

The first trades unions in the world were founded in England, and they too were started within the sphere of the Protestant church - by the Methodists.

In the cultures of these countries there is a greater sense of balance, and even debates involving opposing groups rarely deteriorate into brawls. Huxley, a great propagator and defender of Darwin's work came face to face with Bishop Wilberforce in a public debate in Oxford which was conducted with great politeness. In such contests politics and culture proceed more by means of successive adjustments than by lunges and reposts.

On the other hand, in those cultures which can be traced back somehow to the French Revolution there has always been a frightening swing between radical revolutions and counter-revolutionary holy alliances. Thus people have been driven to take up position on one of the two fronts, and as we know, under battle conditions you easily lose your sense of proportion and the adversary becomes demon-like. It is therefore understandable that people become blinded in the fight and lose their sense of proportion, but that does not justify it.

C. ABIOGENESIS AND EVOLUTIONISM: A SINGLE CONCEPT

In abiogenesis and Evolutionism the same principles are applied. In both cases complexity arises spontaneously from simplicity as a result of chance (which produces the different varieties) and selection (which chooses the most suitable types).

Substantially life in its great complexity is supposed to be written into matter, which is able to produce it and develop it: if God exists, He has acted in a completely indirect way. Benedetto Croce observes that «In as far as Darwinism accepts the philosophical, or unconsciously contains within itself a philosophy of its own, it is pantheistic dynamism and cannot be reconciled with the idea of a personal God» (8). To make this clearer, pantheism attributes to the physical universe the characteristics of divinity; thus all reality is God. In practical terms the biblical existence and power of God is replaced by that of the created order. Matter with its laws, the world, and the universe, all become The Absolute.

As confirmation of the conceptual unity between abiogenesis and Evolutionism let us recall Darwin's stand in favour of abiogenesis (ch.2/F). The evolutionist Lamark also held to spontaneous generation.

To conclude, if evolutionists are to be consistent, belief in abiogenesis is indispensable so that they can fit both the origin and the development of living beings into the same framework.

«Today spontaneous generation lies at the route of evolutionist theories as a theoretical possibility, as a phenomenon which needs to be verified, but which we are unable to reproduce in the laboratory today and which is not observable in nature» (9). These words were written in 1950, but they still correspond perfectly to the present situation.

APPENDICES AND FOOTNOTES

NOTES ON CHAPTER 2

(1) F. La Guardia, *Il popolo dei caribù*, in Quadrante no.15/16, 1986, pp.54-55.
(2) *Enciclopedia italiana,* 1950, headword *Generazione spontanea.*
(3) See P. Omodeo, *Creazionismo ed evoluzionismo,* Laterza, Bari, 1984, p.4. Where not otherwise specified, this is the work by Omodeo that we will mention in op. cit.
(4) L. Monfroni - C. Pavanati Bettoni, *Elementi di biologia attiva per le scuole medie superiori,* ed. Signorelli, Milano 1980, p.9.
(5) P. Omodeo, quoted by P.Polito in his introduction to F. Redi's *Scritti di botanica, zoologia e medicina,* Milano, 1975, p.10.
(6) Ath. Kircher, *Mundus subterraneus,* Quoted by P. Omodeo, op.cit., p.7.
(7) *Idem,* p.9.
(8) J. Rostand, *Lazzaro Spallanzani e le origini della biologia sperimentale,* Einaudi, 1963, Torino, p.16.
(9) See note on *Joshua 10:11-14* in the *Catholic Bible* published by Paoline (1986)
(10) P. Rossi, *Galilei,* Compagnia Edizioni Internazionali, Milano, 1966, p.47.
(11) P. Rossi, *idem,* p.48.
(12) P. Omodeo, *op.cit.,* p.10.
(13) F. Redi, *Opere,* vol.1, p.117 of the Venezia edition of 1972. Quoted by P. Omodeo, op.cit., p.9.
(14) For the first three points see *Mark 8:1-10,* for the other two points see *Matthew 15:33* and *John 6:12.*
(15) See V. Marcozzi, *Le Origini dell'uomo,* Massimo, Milano, 1983, p.9.
(16) P. Omodeo, *op.cit.,* p.112.
(17) P. Omodeo's *Introduction* to: Darwin, *The Origin of the Species,* Newton Compton Italiana, Roma, 1974, p.8.
(18) P. Omodeo, *op.cit.,* pp.60-61.
(19) *Idem,* p.66.
(20) G. Montalenti, *Spallanzani nella polemica fra vitalisti e meccanisti,* in *Lazzaro Spallanzani e la biologia del Settecento. Teorie, esperimenti e istituzioni scientifiche,* compiled by G. Montalenti and P. Rossi, editor Leo S. Olschki, Florence, 1982, pp.9,15.
(21) P. Omodeo, *op.cit.,* p.67.
(22) *Idem,* pp.29-31.
(23) G. Montalenti, *op.cit.,* p.9.
(24) J. Rostand, *op.cit.,* p.32.
(25) *Idem,* p.42.
(26) *Idem.*
(27) G. Montalenti, *op.cit.,* p.6.
(28) i.e. in one go.
(29) P. Omodeo, *op.cit.,* pp.68-69. Emphasis ours.
(30) L. Pasteur, *Opere,* edited by O. Verona, UTET, Torino 1972, pp.991, 1001, 1003.
(31) J. Rostand, *op.cit.,* pp.19,20.
(32) *Idem,* p.20.
(33) C. Bonnet, Quoted by J. Rostand, *op. cit.,* p.188.
(34) J. Rostand, *op.cit*., p.7.
(35) *Idem,* p.183.
(36) *Idem,* pp.35,36.

(37) J. Rostand, *op.cit.*, p.41. In the last sentence Rostand is quoting M. Caullery.
(38) C. Castellani, *Lazzaro Spallanzani nei suoi rapporti con la scienza e la cultura de Settecento,* in *Lazzaro Spallanzani e la biologia del Settecento, op.cit.*, p.25.
(39) *Idem,* p.24.
(40a) *Idem,* pp.41-43.
(40b) *Enciclopedia Italiana,* 1949.
(41) V. Marcozzi, *op.cit.*, p.17.
(42) P. Di Pietro, *Rapporto tra Lazzaro Spallanzani e la biologia del Settecento, op.cit*., p.25.
(43) L. Pasteur, *Opere,* edited by O. Verona, UTET, Torino, 1972, pp.385-481.
(44) F. Bonora, *Pasteur e la cura della rabbia,* Ed. La Scuola, Brescia, 1982, p.102.
(45) O. Verona, *Introduzione a L. Pasteur, op.cit*., p.33.
(46) *Idem,* p.34.
(47) F. Bonora, *op.cit*., p.107.
(48) J. Rostand, *op.cit.*, p.31.
(49) O. Verona, *op.cit*., pp.378-379.
(50) L. Terrenato, E. Di Mauro, *Guida alla mostra "5 miliardi di anni. Ipotesi per un museo della scienza",* organised by the University of Rome and others in Rome, Palazzo delle Esposizioni, 29th May - 31st July, 1981, p.76.
(51) J. Segal, *Miciurin, Lysenko e il problema dell'eridita`,* ed. F. Lanza, Universale Economica, Milano, 1952, p.70.
(52) F. Bonora, *op.cit*.,p.106.
(53) In Greek letters in the text.
(54) L.Pasteur, *op.cit.*, p.1004.
(55) *Idem,* p.991.
(56) *Enciclopedia Italiana,* heading Newton, ed. 1949.
(57) O. Verona, *op.cit*., p.34.

NOTES ON CHAPTER 3

(1) P. Rossi, *op.cit.*, p.68.
(2) *Idem,* p.61.
(3) L. Spallanzani, *Opuscoli di fisica animale, e vegetale, op.II, sez. II,* quoted by J. Rostand, *op.cit.*, p.102.
(4) *Shalom, n.1/1987,* p.20.
(5) Einstein, *Come io vedo il mondo,* Newton Compton, Roma, 1975, pp.29-30.
(6) H. Muscalek, *Dio e gli scienziati,* Paoline, Alba, 1972, pp.30-31.
(7) *Enciclopedia italiana,* 1951.
(8) Quoted by J. Rostand, *op.cit.*, p.35.
(9) J. Rostand, *op.cit.*,p.137.
(10) *Idem,* p.138.
(11) *Idem,* p.137.
(12) G. Montalenti, *Spallanzani nella polemica ..., op.cit.*, p.14.
(13) A. Hallam, *Le grandi dispute della geologia,* Zanichelli, Bologna, 1987, p.176.
(14) A. Hallam, *Alfred Wegener e l'ipotesi della deriva dei continenti,* in *Le scienze, n.82,* 1975, p.74-83.
(15) A. Hallam, *Le grandi dispute ..., op.cit.*, p.129.
(16) A. Hallam, *Alfred Wegener ..., op.cit.*, pp.74-83.
(17) *Idem,* p.82.
(18) P. Rossi, *op.cit.*, pp.26-27.
(19) A. Hallam, *Le grandi dispute ..., op.cit.*, pp.175-176.

(20) L.Pasteur, *op.cit.,* pp.1003-1004.
(21) *Idem,* p.1001.
(22) H. Muschalek, *op.cit.,* p.25.
(23) *Enciclopedia Europea,* Garzanti, Milano, 1978.
(24) W. P. Jolly, *Guglielmo Marconi. L'uomo, lo scienziato, l'inventore,* Mursia, Milano, 1974, p.10.
(25a) A. Hallam, *Le grandi dispute ...,op.cit.,* p.124.
(25b) K. Popper, *Corriere della Sera,* 14/4/1989, p. 3.
(26) See the article by D. Di Rio, *La Repubblica,* 5/11/85, p.4.
(27) *Idem.*
(28) *Idem.*
(29) F. Dostoevskij, *I fratelli Karamazov,* Mondadori, Milano, 1966, pp.14-19.
(30) We are indebted to Prof. Mariano Bianca for the lessons on the epistemology of science held in Cortona (Italy) in 1984.
(31) F. Bonora, *op.cit.,* p.156.
(32) L. Pasteur, *op.cit.,* p.1001.

APPENDICES TO CHAPTER 4

The simplifications and rounding off in these calculations have been done in such a way as to weaken the argument we are presenting.

We realize that there are some who will not be able to follow these calculations, but they can always have them checked out by others more competent than themselves.

Appendix no. 1

The cost of 2^{60} beans

2^{60} beans = $(2^{10})^6$ = $(1024)^6$ = approx. $(1{,}000)^6$ = $(10^3)^6$ = 10^{18} beans. There are approx. 2,000 beans in a kilo. If we take the price of beans to be 2 dollars a kilo, one bean would cost 0.001 cents and 10^{18} beans would cost 10^{15} cents, i.e. $100,000,000,000,000 which is one hundred thousand billion dollars; that is the cost of 2^{60} beans.

Appendix no. 2

The time it would take for a billion monkeys to type the sentence "evolution is the best"

So as to help the monkeys, who are striking at random, we will give them type-writers with just 20 keys which correspond to 19 small letters, plus the space bar.

Since there are 20 keys, the first letter, i.e. the "e", will be struck on average once every 20 times, but to type the first two letters, i.e. "ev", 20^2 (400) strokes of the keyboard will be required. In fact there are 400 possible combinations of 2 letters (aa, ab, ac, ...;ba, bb, bc, ..., ca, cb, cc, ..., etc.).

The first 3 letters ("evo") will be typed every 20^3 strikes and the whole sentence of 21 letters and spaces will require on average 20^{21} strikes = $(2 \times 10)^{21}$ = $2^{21} \times 10^{21}$ = $(2 \times 2^{10} \times 2^{10}) \times 10^{21}$ = $2 \times 1.024 \times 1.024 \times 10^{21}$ = approx. $2 \times 10^3 \times 10^3 \times 10^{21}$ = 2×10^{27}; this is the total number of strikes needed.

Calculating on the basis of 5 strikes per second, in one year a billion monkeys would strike their keyboards approx. 2×10^{17} times. Since they have to strike them 2×10^{27} times, they will need 10^{10}, i.e. **10 billion years;** this is the time it would take on average for a billion monkeys to type that phrase.

Appendix no. 3

The volume of protein that would need to be produced before one was produced by chance.

We will consider a very short protein, one made up of just 100 amino acids. Our calculation is similar to the one in the appendix before.

As there are 20 different types of amino acid, from them there can be formed 20^2 distinct duplets, 20^3 triplets, and so on until we reach 20^{100} different types of protein each having 100 amino acids. But $20^{100} = (2 \times 10)^{100} = 2^{100} \times 10^{100} = (2^{10})^{10} \times 10^{100}$. If we make 2^{10} equivalent to 10^3 we have $(10^3)^{10} \times 10^{100} = 10^{30} \times 10^{100} = 10^{130}$; this is the average number of proteins necessary to obtain the one we are looking for.

If we even up the average molecular weight of the 100 amino acids in our protein to 100 Daltons, it will weigh 10,000 Daltons (or 10^4 Daltons) and our 10^{130} proteins will weigh 10^{134} Daltons. To convert this weight into kilograms we will need to divide it by Avogadro's number (the equivalent of 10^{24}, which will give the weight in grams) and also by 1000 (to turn it into kilograms). This gives us 10^{107} Kilograms, which is the weight of proteins required on average before we can expect the one we are looking for to be formed by random chance.

If we suppose that the proteins have a specific weight equivalent to that of water, this will give us 10^{107} kg = 10^{107} dm^3 = 10^{95} Km^3, being the total volume of the proteins. By calculating the cube root of this volume we will discover the length of the side of the cube which would contain our proteins -the equivalent of approx.10^{32} Km.

A rocket travelling at the speed of light (300,000 km per second) would cover "only" 10^{13} kilometres in a year. To cover the length of a side of our cube measuring 10^{32} km it would take 10^{19} light years, or in other words **10 billion billion light years**. That is how long it would take to cover the length of the side of our cube containing the number of incorrect proteins that would need to be passed by on average before we came up with the right one by chance.

NOTES ON CHAPTER 4

(1) A. I. Oparin, heading *Vita* in *Enciclopedia Europea,* Garzanti, Milano, 1981; I. Adler, *Come iniziò la vita,* Longanesi, Milano, 1979.
(2) e.g. F. Prattico, *Alle origini della vita,* in *Storia illustrata,* no.361, Dec.,1987, pp.46-55.
(3) F. Crick, *L'origine della vita,* Garzanti, Milano, 1983.
(4) F. Dyson, *Origini della vita,* Bollati Boringhieri, Torino, 1987.
(5) Einaudi, Torino, fourth revised edition, 1975, pp.203-210.
(6) F. Crick, *op.cit.,* pp.73-75.
(7) *Idem,* p.75.
(8) J. Monod, *Il caso e la necessità,* Mondadori, Milano, eighth edition, 1976, p.49.
(9) *The Divine Comedy* is made up of 100 cantos, each consisting of 140 verses. In each verse there are 30 letters. The total number of verses is therefore 100 x 140 x 30, or in other words approximately 420,000 letters. A protein consists of an average of 500 amino acids, 2,500 proteins will therefore contain 2,500 x 500 = 1,250,000 amino acids. This represents triple the number of letters in the Divine Comedy, more than those necessary to write the entire New Testament (for which less than 1.000.000 strokes were used).
(10) F.Dyson, *op.cit.,* p.36.
(11) *Idem,* p.79.

(12) F. Crick, *op.cit.,* p.46.
(13) *Idem,* p.76.
(14) H. Curtis, *Invito alla Biologia,* second edition, Zanichelli, Bologna, 1980.
(15) F. Crick, *op.cit.,* p.77.
(16) *Idem,* p.44.
(17) V. Scardi, heading *Amminoacidi, Enciclopedia Europea,* Garzanti, Milano, 1976.
(18) F. Crick, *op.cit.,* pp.53-54.
(19) A. I. Oparin, heading *Vita, Enciclopedia Europea,* Garzanti, Milano, 1981.
(20) F. Dyson, *op.cit.,* p.22.
(21) T. Heinze, *Creazione od Evoluzione ?,* ed. Centro Biblico, Napoli, 1976, pp.75ff.
(22) F. Prattico, *op.cit.,* pp.54-55.
(23) F. Crick, *op.cit.,* p.85.
(24) *Idem,* pp.136-137.
(25) F. Dyson, *op.cit.,* p.56.
(26) P. Angela, *Viva l'errore,* in *La Repubblica,* 12/3/88, p.26.
(27) F. Dyson, *op.cit.,* p.97.

NOTES ON CHAPTER 5

(1) F. Crick, *op.cit.,* p.86.
(2) G. Montalenti, *L'evoluzione, op.cit.,* pp.206-207.
(3) F. Dyson, *op.cit.,* p.45. Emphasis is ours.
(4) B. Croce, *La storia come pensiero e come azione,* Bari, 1966, pp.269-272.
(5) *Grand Dictionnaire Universel du XIX Siecle* by P. Larousse (1872), heading *Génération,* quoted by G. Sermonti in Dopo Darwin, Milano, 1980, p.23.
(6) See J. Monod, *op.cit.*.
(7) G. Josca, *La resurrezione di padre Jacksok, Corriere della Sera,* 12/3/88, p.3.
(8) By I. de Feo, *Croce, l'uomo e l'opera,* Mondadori, 1975, p.214.
(9) *Enciclopedia Italiana,* heading *Generazione Spontanea,* 1950.