Studies on Time:

1) Time in Astronomy;

2) Time in Mathematics;

3) Time in Biology

1) José Antônio de Freitas Pacheco;
2) Francisco Miraglia;
3) Erasmo Garcia Mendes

Institute of Advanced Studies of the University of São Paulo

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Presentation

The temporal dimension of phenomenons is a philosophical, methodological and experimental concern for several knowledge areas, in the field of arts and human sciences and also in the exact and natural sciences. It can be analyzed from the perspective of its generality, as a natural dimension, through philosophical questions regarding its essence. It can, on the other hand, discuss different appropriations of time by several disciplines, through questions of how time is incorporated and dealt with by several areas of human knowledge.

The proposal of an interdisciplinary approach to discuss this and other issues on time led to the constitution of GET - Grupo de Estudos sobre o Tempo (Group for Studies on Time) in February 1989, connected to the Institute for Advanced Studies in the University of São Paulo.

Since then, this Study Group has met systematically in the headquarters of IEA/USP for seminars and debates on several aspects of issues of time in several disciplines, always with a perspective of interdisciplinary interaction. It also organized several round table discussions and public conferences in and out of USP.

One of the results of this group's work is now in your hands. We have grateful satisfaction of starting the publication of documents produced by GET through this special series in the Document Collection by IEA. With this we intend to show the public the transcription of several round table discussions, conferences, symposiums and internal debates that GET has organized and participated in several instances.

Nelson Marques and Luiz Menna-Barreto

Coordinators of the Group for Studies on Time - IEA/USP

TIME IN THE NATURAL AND EXACT SCIENCES

L.B.CLAUZET: Since 1988 a multidisciplinary group has met to discuss issues of time. This group, sponsored by the Institute for Advanced Studies in USP, and coordinated by colleagues Nelson Marques and Menna-Barreto, has been doing monthly debates where specialists from different areas are invited to speak. The aim of these debates is that each participant, even if not working directly with the theme, will informally, to a more ample public, approach aspects related to the problem of time, from the point of view of his area of expertise. It is with great satisfaction that I coordinate the round table today, entitled Time in natural and exact sciences. The representative areas chosen were Astronomy, Mathematics and Biology, intrinsically related to time. Professor Erasmo Garcia Mendes is a widely known person, a scientific patrimony of this University, dispensing greater introductions. Doctor Francisco Miraglia is one of those rare people who co-exists contemplation humanity with and untiring action humanity, transmitting to all the flame of the possibility of a better world. Professor José Antônio de Freitas Pacheco, one of the most dynamic and active astronomers in our time, is one of the people responsible for modern Astronomy developed today in Brazil. I thank you all for your presence. I will give the floor to Pacheco, then Miraglia and then Erasmo, following the chronological historical order of the emergence of the disciplines in which they work.

With the floor professor Freitas Pacheco, who will speak on TIME IN ASTRONOMY.

J.A.F.PACHECO: First of all I would like to say that I am not a specialist on issues of time. And when Clauzet invited me I wondered if I should give an astronomer's opinion, in this case my own, who was invited to speak about time, or effectively give the opinion of an astronomer regarding time in Astronomy. I will end up doing what I believe is a mix of both. Time for Astronomy, or for astronomers, or for whoever works in astronomy does not differ much from the concept of time that comes from Physics, a concept that applies to Biophysics, since the physical processes involved imply in equations that are, in their essence, the same, since they are essentially the same physical principles in cause. Our concept of time comes from the fact that time seeks to characterize something that modifies itself with the evolution of a system. Every physical system, whichever it is, evolves, alters, and we seek to somehow associate these alterations with some kind of description, with some kind of variable. We who are here in a movie auditorium could consider, as an example, a sequence of events which happen in a movie, which are represented in each frame. Then let´s imagine that, by some diabolic action, someone takes the movie we are considering and cuts it up, frame by frame. Let us also assume that the editor of the movie, who did not previously know it, now edited all the frames at random. It is evident that, if we watch the movie now, we may have a sequence (if this is an old Wild West movie), where we can see the bandit fall before the good guy takes a shot. Thus, it is evident that when speaking of time a sequence of events is implicit, which is intrinsically tied to a relationship between cause and effect. It is not possible for the bandit to die before the good guy shoots. Thus, in this time sequence, in this order of frames, a relationship of fundamental importance to any physical theory is implied, which is a cause and effect relationship, meaning that the bandit can only fall after the good guy takes a shot. A cause and effect relationship is fundamentally related to the fact that we can order a temporal sequence. It is also evident that, instead of cutting up the film, we can think of screening an inverted film (without cutting it, simply projecting from end to beginning), where we would also see the cause and effect relationship “fail”. In other words, can I go back in time? In order to better understand this concept, let´s examine the following: if we take Astronomy as an example, the movement of the planet around the sun, the equations which describe the planetary movement, the dynamic equations, allow me to predict what the position of this planet will be in the future, if I know the initial conditions, meaning a certain configuration of the planet related to the sun. If anyone has doubt about this, they must remember that a few weeks ago it was known that there would be an eclipse, which lasted one hour and a half (in fact it was a previous prediction, a prediction of the "future" that allowed me to say: look, such and such day there will be an eclipse;which means the moon will pass behind the shadow cone of the Earth and will remain there for a specific amount of time). The dynamic solutions allow me to predict a future situation. In the same way, I could think of the following situation: history says that during the birth of Christ there was a shining star in the sky and we could ask ourselves if this star, this source of light, could be associated, for example, to comet Halley. So, instead of making a future prediction, I could make a "prediction" of the past. In other words, knowing the orbit conditions of comet Halley today, I can ask if two thousand years ago Halley was in a favorable situation to appear in luminous form, at the time of the birth of Christ (we know this is not true, if it was a comet certainly it was not Halley). However, it implies that I can change the sign of time and know a situation from two thousand years ago. Here I have given an example where I have a dynamic system, where if I place a t positive value I can predict the future and if I place a t negative value I can know a past situation. Now let´s examine another situation, another example. We will imagine a completely transparent glass so we can examine the water, which I will call substrate. In this glass I carefully take a syringe with colorful liquid and place a drop of the liquid in this completely immobile glass here. Now I fixate exclusively on the thermal movement of molecules: this liquid, this paint, will go through a diffusion process in the substrate. In other words, the concentration which was huge, which was maximum in the center of the glass, will be diluted in the substrate. Thus, I can always, in a given instant, solving an adequate equation that Miraglia knows well, the diffusion equation, I can know in any instant of time what the particle concentration will be. But let us now imagine that an assistant has arrived late, one hour after I started my experience. He would look at the liquid concentration in the glass, and knowing which equation the process obeys, he could ask: What was the initial concentration of the liquid one hour ago? One would assume that it would be enough to switch t and t in the equation that describes the process, however, if that is done, I obtain a different equation: the process is not reversible. This means that in this physical process I just described it is absolutely impossible, from the conditions known at a certain moment, to know the past. I cannot go back: I can know the future, but I cannot know the past, because my process is irreversible. The existence of a sequential process, which I mentioned before, is profoundly related to the fact that we have a cause and effect relationship. This experiment I just mentioned shows that there are reversible and irreversible processes which are associated to the second law of thermodynamics. The second law of thermodynamics says that when I go from a certain configuration A to a certain configuration B, if during this passage entropy increases, the process is irreversible, and I can no longer return to A. If entropy is maintained constant, this process is reversible, and I can return to process A. Thus, the process I just described is a process where entropy increases, so I cannot return to A, for I would be violating the second law of thermodynamics (I would have to return to a state where the entropy value is lower than the final state). Thus, in a way, the orientation of the time axis, in the irreversible processes, is related to the fact that, if I have a process where entropy increases, this process is irreversible. For example, for a long time in Astronomy the rotation movement of the earth was used as a watch, as a marker of time. However, the earth's rotation is not a perfectly isotropic movement; it does not have constant entropy, so it is not reversible. The earth's rotation due to the influence of the moon, the sun, which provoke tide forces, and dissipate energy are not isentropic, do not have constant entropy, and thus are irreversible (in this case the earth would not be an ideal watch; I cannot go back because when I go from stage A to B the entropy is altered). Time, in its physical definition today, is seen from an atomic definition, a definition where I use as frequency pattern the emission of an atom (for example, the cesium atom or a ruby crystal, which have very well determined frequencies). The other issue we can raise is that if this time, even this time that is atomically measured, which is atomically defined, is uniform and the same for all observers. Fleming, in an article he wrote for USP magazine, mentioned that time occurs in a diverse manner, according the reference system of the observer, and I will not discuss what he presented in the article. But there is still another effect: the structure of our space-time is determined by the distribution of the gravitational masses, meaning the distribution of matter in the universe. Without going in to great detail on this problem, the frequency of the atom depends on the close presence or not of matter. In other words, if I have an atomic watch, a cesium here on earth, where there is a certain matter distribution, and approximate this same watch now to the sun, which has a greater matter concentration, what will happen? The transition frequency will increase. If I go further away from the sun it will decrease. This is an effect predicted by the general theory of relativity, called "detour to the gravitational red", which depends solely on the distribution of matter. It can be better thought or examined, more dramatically, if we look at the effect of a falling star, originating a black hole. We can imagine the case of an observer that is on the surface of a sinking star with his quartz watch, and another observer, far away, which is much safer and will not sink with the star. What happens? As I said, he who is in the presence of an intense gravitational field has his watch ticking with a much faster frequency. For the one who is distant the frequency is lower. Thus, this distant observer will observe the collapse process: the "astronomer" falling from the surface of this star's horizon. This will happen, for this distant observer, in an infinite time. In reality he will never see this happen because the object will no longer be visible for other reasons. However, if he could observe ad eternum the distant observer, which is on the surface of the object, he would only see the "astronomer" effectively reach the surface of the horizon (which means, when the collapse is complete), in an infinite time. However, for the observer on the surface, who is sinking with the star, the frequency of his clock depends on the gravitational field and this field increases more as the star collapses, and he sees, in a finite time, the collapse occurring. It is evident that the passing of time, although having an atomic pattern, physically depends on the presence of a gravitational field, and this also influences the biological passing. It is not only an apparent effect: because if it influences the atomic "vibration", it also influences the natural frequencies, the chemical and biological processes. Of course biologically we would feel this temporal alteration, which occurs for the distant observer and for a close observer in an intense gravitational field. Another issue, another important aspect to be approached (now that we have more or less seen that the passing of time is related to cause, to entropy, and that the passing is not uniform for observers situated in different areas of space) is the origin of time. I mean, was there an initial instant from the cosmological point of view? Or does counting time happen ad infinitum, from past to future, also with no ending perspective – an eternal universe? From Astronomy's point of view there are at least three reasons, completely independent from each other, that lead us to assume the existence of a beginning. The first is related to the reciprocal distancing of the galaxies, which is interpreted to be due to universe expansion. Besides the reciprocal distancing of the galaxies, another evidence of universe expansion is related to the fact that night is dark. If there were not an area called horizon, where galaxies distance at the speed of light, night would be light, and not dark. And since nigh is dark (a fact proven by observation), it implies that the universe is expanding. And if we then use a direct measure of the reciprocal expansion of the galaxies, we can determine a time scale, from which the universe would have initiated its expansion. This would have occurred, within the uncertainty of these measurements, in a time around fourteen more or less three billion years ago. But that is not all. Another evidence comes from the study of the older stars, located in globular agglomerates (which are first generation stars in our galaxy). We can determine the age of these stars solely through nuclear processes.

We know the efficiency of nuclear relations, we know the efficiency of the reactions which produce energy, we measure the energy these stars are producing and we can, therefore, determine a scale of nuclear time. This time scale is the in the order of fourteen more or less three billion years of age. See that these two numbers, which are determined in completely independent manners, in spite of uncertainties, are in accord. But there is also another evidence that the universe had a beginning: the fact that on the earth and other planets from the solar system there are still radioactive elements, such as uranium and thorium. These elements, in spite of having an extremely long average life, in the order of billions of years, if the universe were infinite they would not be observable for a long time past, they would have transformed into lead. The fact that radioactive elements still exist give us certainty that there was a beginning, there was a fiat-lux. And as we know, through nuclear physics, the capacity the stars have of producing heavy elements, we can also, through the amount of heavy elements related to lead, determine an age for the galaxy, which results in the order of thirteen more or less four billion years. So we see, through the distinct processes, the measurements and observations, that we are led to numbers that agree with each other, which make us believe there was a fiat-lux approximately fifteen billion years ago, with an uncertainty of, say, three billion years. Another interesting issue that can be raised is that, if today the knowledge we have of physics allows us to describe the beginning, is it possible to have an idea of the future that awaits us? What will be the end of the universe? In how much time will we reach a state of maximum entropy, where nothing more will be possible? There will no longer be reversible processes, there will no longer be a way to extract energy from the universe. There are some phases related to the future that we can mention. The universe following a story through path A or path B depends on the modern unification theories, if they are correct or not. These theories which lead to the unification of the different forces of nature, predict, for example, that the proton is not a stable particle and would have an average life span of 10^{33} years. However, although the universe is much younger (the age I mentioned is in the order of ten to fifteen billion years, few protons would have decayed), it is possible to measure an extremely small fraction of protons which disintegrated. This would be measurable. Up to this moment this was not measured in laboratory. If the decay of the proton does not happen (if the theories are incorrect) the universe will continue its life beyond 10^{33} years. Thus, we could ask what the future phases are. Those who had the opportunity to read "A brief history of time" learned that Hawking imagined a process through which, due to a purely quantum effect, the black holes, even those with a great mass, every so often emit a particle. The evaporation, due to the Hawking effect, of eventual black holes that can exist in our galaxy (they are minimal energy states, and nature always seeks minimal energy states for stable situations) would take around 10^{64} years. After this we would still have another possibility to think of a way where nature will seek lower energy levels. The planets and the stars, which have a very dense configuration, can be imagined as a "crystal". There is a probability, different from zero, of the atom that is fixated in this crystalline net being able to escape it. This represents a very long time, but when atoms escape from this crystalline net, also by a purely quantic effect, the planet is no longer a solid and starts behaving as a liquid. Thus, the fluidization time of all crystals in all planets represents a time of 10^{176} years. But this is still not the last stage; it is not the "end of time". There is still a lower energy state that matter can reach. After reaching this fluidization state, there is the possibility that all existent nucleuses transform into iron nucleus (nucleus with greater ligation energy, and the most stable). Thus, there is an "ironing" process and this will happen in 10^{10480} years. If you are surprised with such a large number, it is still not the last possible stage, to our knowledge, in which matter finds its minimal energy. The minimal energy stage is when all of these iron nucleuses transform intro neutrons, and then there is a complete "neutronization" of matter and this is then the "end of times", for we will reach the state of maximum entropy and nothing more can be taken from the matter present in the universe. It is the state of complete death, which we will reach in $(10^{10})^{76}$years. This is the number of the apocalypse, the number of the "end of times". I finish my part saying that "whoever lives will see".

L. B. CLAUZET: Thank you Pacheco. I now hand the floor to Francisco Miraglia, who will talk about TIME IN MATHEMATICS.

F. MIRAGLIA: I would like to thank you for the invitation for this conversation. There is a general difficulty, which I share, in the explicitness of issues related to time. There are many times of which to speak of. Every time we need to divide a reflection on this theme there is confusion. I remember that Saint Augustine said: “I know what time is, except when I am asked, because then I don´t know how to explain”. I am a professor of mathematics which has become, in the course of three thousand years, a scientific language. You heard the previous lecture mentioning equations, data, manners in which things articulate, referenced in mathematical terms. I want to comment and discuss with you a different perspective of time comprehension. We could think of the clock as being the “idea of a clock”, a repetitive pulse, recognizable and used as a pattern. The clock is essentially this: what the cesium atom does, what the earth’s rotation does, and this idea can be referenced in many things. For example, in the pulse of discipline, in mathematics itself, in the human activity, there is this axis of time through which you try to measure evolution. But it also has its problems from the point of view of how it happens in the progress of humanity, it has its pulse, its movement. I would like to focus on this issue, related to mathematics. From the historical point of view, if we look at the mathematics we know, the first existing records are from Ancient Greece. What is the sum and origin of the problems there? Essentially it was the sum of problems that originated from the knowledge of solids in space and which came from a great interest in astronomy, a long standing object of human interest. Besides the issue of solids, meaning how things relate to space and what possible reactions are between them, the issue of how these relations modify arises. Then there is the beginning of a chronological issue. Besides this, in the quantity relationship, which were the manners with which we could think and create symbols that could make the quantity articulations treatable in a methodical point of view? This is not a simple matter and many times we do not think of this. Multiply four hundred and thirty seven by one thousand four hundred and ninety in roman numbers: either you know the result or you won’t be able to do it. The Arabic numerals include, besides the capacity of expression, the possibility for operations. This drastically changes the relationship with these numbers. Firstly, in the amount of knowledge that can be produced and the amount of knowledge that can be obtained. Secondly, it is unthinkable to do this, as history shows us, without a process of abstraction, which again happens in time, from the need to produce knowledge. In other words, the numerals we learn since childhood, the Arabic numerals and the positioning system are drastically different from the roman numerals, drastically different from what the Chinese use to represent the idea of numbers. Why? Because they are not simply names, they are a method to give names. Intrinsically, the numbers are infinite, we don´t have a name for each number. What we learn in reality is that, if we want, we can find a name for any number, which is completely different. In general this comes together, that was the collection of problems that were there. Evidently the issue of Arabic numerals, the positional dating, came much after those worries that were there. It is instructive, for example, to apprehend how Euclid enunciated his theorems on arithmetic. These highly important theorems were enunciated in an extremely "long-winded" manner when compared to what we know today. The Greek problematic tried to build the critic of knowledge on movement, and again incorporated the problem of time and the problem of process. But from the mathematical point of view, there was again an abstraction, as with the case of numerals. I want to understand how the possibility of dividing, meaning to arrange increasingly smaller pieces, and be able to understand the movement looking globally, looking at what is divided. The Greek school and the Eleatic school proposed some of the fundamental bases for the comprehension we now have of the processes of limits, meaning that I know something, I know what it is, I know what happens with the objects which are the result of the succession of these things. The Greeks did not solve, but pointed to the problematic of limit, meaning how you discover what is happening in the limits of what you know. For example, the problem of area, the problem of volume, the problem of calculated chopped speed, all these things appeared there. Today if you look at this structure, at the mathematical activity that developed much as a language for science, from this internal point of view it continues essentially, basically, the same way it was there. Meaning that in the last two thousand years we have produced a considerable amount of knowledge about the same problems. How much is known about the natural numbers today? More is known than we knew one hundred years ago, but there is no in depth knowledge of the structure of the natural numbers, these numbers we use to count. For example, how is the distribution of prime numbers, meaning, how is the distribution of numbers that don't have dividers. No one knows! These issues still stand today. There are problems of space geometry, for instance, how you characterize the Poincaré conjecture in dimension three is still open today. This means that on this set of problems an edifice was erected, built in history, therefore, in time. But from the internal point of view of the subject, the fundamental set of problems that are there advanced, but continues to be the exact same set of fundamental problems. It's as if you had two types of clocks. From the point of view of the inside of the subject the things that are substantial, that are done today, are to try to solve problems that, some of them, have been standing for tree hundred, three hundred and fifty years. In parallel with this issue, the mathematical science produced in the strength of its needs. And what are the fundamental needs? The fundamental need is to produce, inside mathematics regarding its applications, regarding the history in which it is inserted, to produce symbolic equipment that is synthetic and calculable. And this is what makes mathematics a language for other sciences, particularly for the Physic Sciences (Mathematics is much closer to Physic than to Chemistry; closer to Chemistry than to Biology; closer to Biology than to Social Sciences). This approximation is another axis to discern evolution. This means that in speaking to you I do not want to fixate on an axis and say: Let us examine what happened in 1793! I am trying to point to another perspective, which is the perspective ofthe contribution mathematics brings to itself, how it pulses, how it interferes in other sciences. Tied to Physic and Astronomy, closer to Chemistry, particularly in the twentieth century, and further from Social Sciences. The mathematical equipment used in Social Sciences is absolutely primitive, it is comparable to what was used two thousand years ago to study vibrating cords, meaning to divide proportionally to see the vibration frequency. So it is important to analyze the issue of use, the relationship of science with itself in its evolution, how it pulsates; and also its relationship with other categories of scientific and philosophical interest. It is possible to trace, regarding the perspective of human activity, an axis, which while still located, is an axis of intense debate, which is the following: What is mathematics? How was the mathematic activity conceived? The mathematic activity was conceived as a general theory of relationships, and in this measure it acquires the capacity to express a huge variety of phenomenons. However, it is a general theory of relationships. There is a preconception (I think it is a preconception and here I am blatantly giving my opinion), according to which intuition, meaning, the general theory of relationships which is extracted from the relationship between solids, or extracted from the counting relationship, is the same intuition, is the same relationship theory that would be appropriated to study socio-politic phenomenons. I am saying this may be false. Intuition, meaning, the general theory of relationships, which would be necessary to study other phenomenons may be another, different from the one which we obtain studying a solid in space or trying to understand how to count or how things order themselves. This means that there are other possible mathematics and opens an objective perspective. But this is an evidently philosophical discussion. On the other hand, to finish, I would like to tell you this. From the point of view of progress, of advance, we can discern today an extremely complex edifice which is mathematics, an esoteric edifice, of difficult transmission and explanation for people in general. Most of the comprehension of mathematics comes precisely from its application in other sciences. This application generates problems and generates interaction and most of the comprehension that we have outside of the collective of people who are professional mathematicians is generated by its use in another activity. This is not new, this is classic in time, and on the other hand, influences how the science itself functions. This means that the more physicists and astronomers propose to understand the world or the universe as we observe it, greater is the set of problems generated internally in mathematics, in the process of helping to build this general theory of relationships that can serve to express, to make calculable, methodologically treatable, this set of problems which is there. The examples are many and the most recent is the theory of super-varieties to merge the general field theory. Super-varieties, etc., which are things that "appeared" in the minds of physicists and astronomers and they went and asked the mathematicians, "how is it done?", "what is this?" This means that there are mathematically interesting objects that are generated outside the discipline today, and this is part of the history of Mathematics. Very well, this interaction, the pulse of this "to do", in reality is intrinsically linked to the human activity in the past three thousand years. Archimedes was a person who had absolutely fundamental ideas, he was interested in resolving extremely practical problems, "if Syracuse was surrounded, how would I throw a stone from this side on the invading army's head?" It is then necessary to discuss the support, the issue of stretching and then cutting the rope, and thus the catapult was invented. Or the buoyancy problem, to study the issue of the boat. Therefore, there were extremely basic and important socio-politic issues that occasioned this type of reflection. The mathematical activity today is somewhat untied, meaning the activity from the point of view of the producer of knowledge; most of the knowledge produced by mathematicians is essentially untied from this process of fitting their work in the historic perspective of the science. We have a huge number of production publications, but if we follow the fundamental expression of the mathematical thought in each fifty year period we will see the resuming of fundamental issues of understanding the relationships solids can have in space, the nature of the numbers, the types of numbers we have, and the possibilities of expression of other general laws and other general theories of the relationship of mathematics to other disciplines. Time, in this sense, in the sense of what happens with science, of the relationship with others and how these things interact has a clock and a rhythm that is much, much slower than the count of time in years. It would be necessary, including in the scientific activity itself, to have clarity regarding this issue, because this will reflect, objectively, the scientific activity itself in the practical sense, of which issues I attack and how I reflect on these issues, what their story is. Lastly I would like to say this: Pacheco represented, very well in my opinion, a perspective regarding time in which we ask if there is a pattern of behavior which can be discernible (observationally) for the universe in which we live and that somehow is the idea of time we use, time on the clock, time measured in years, whichever you use. There are other patterns of behavior regarding time and knowing the difference between these clocks is important, meaning that the issue of how a science grows and in what time it grows. We also have the notion that there is a determined set of issues that are culturally saturated. Thus, the Greeks did not have the methods and means to solve the issues they proposed and two thousand years later we remain having resolved only a few. Some others they proposed we also cannot solve. Thus it is possible to measure time by the power you have, meaning that we understand time as the power you have to solve and comprehend certain fundamental problems that are those of always, which I have mentioned several times. This is a notion through which you can discern the socio-politic influences that exist in making science. This means, what happened in the Middle Age or in the nineteenth century, what happened in the beginning of the twentieth century? It is possible to discern more clearly the flow of this if we carefully accompany what is happening, what changed and where it went. Thus, it is possible to discern the socio-politic influences that exist in making science itself. The intensity with which the scientific community is charged in a production perspective, at least in my activity area, produces an enormous amount of material where it is not always simple to separate what is important from what is not. If, on the one hand, this is a type of richness, because many people are thinking and doing, on the other hand it is seen, in this progress, as extemporaneous regarding the central issues that are placed in the historic point of view, which we would like to comprehend. We would like to learn what happens with the polynomials (I believe everyone knows what am I am talking about), what is an equation involving potencies, the distribution of prime numbers, and the relationship between solids, this is fundamental. On this fundamental an edifice was build which involves examining also the fundamentals of how we think, which is my professional specialty. I am a logician. How are sentences organized, what do they mean, what are the possible interpretations a sentence has, all this is part of the methodological problem of understanding solids and numbers, polynomials and all these issues. Thank you.

L.B.CLAUZET: I now hand the floor to the last lecturer, Professor Erasmo Garcia Mendes, who will speak about TIME IN BIOLOGY.

E.G.MENDES: I would like to state, first of all, that my voice is somewhat raspy, forgive me. I am also not a specialist on issues of time, or time in biology. However, some time ago, a friend of mine called Menna-Barreto invited me to participate in this seminar, which I understood as a Chronobiology seminar and told him I knew little of Chronobiology, except for the fact that in my experiments I always consider the time factor, because for animals the course of time in one day is very important. Thus, I do not consider myself an expert in the subject, but I will try to give you a view of the importance of time in biological research. Time, biologically considered, is not Einstein time, the time of Physics; it is not even the philosophical time of Martin Heidegger, for example. It is time in the measure in which organisms live in a sequence of periods and have to adapt to these periods. Life appeared on earth around two billion years ago, and since there are life forms on Earth they have been subjected to day and night alternations (the astronomer will correct me if I am wrong). The alternations of seasons, the alternation of temperature, and the forms which evolved had to somehow adapt to these environmental periods. Besides the environmental periods more visible such as light, temperature, feeding time (animals have a certain time to feed), there are also subtle geophysical periods, like the electromagnetic field, and eventually also the Coriolis Effect, which could interfere in the context in which animals should habituate to for their activities. Of course animals, in time and somehow, and this is still very mysterious (and if I am wrong my colleagues Menna-Barreto and Nelson Marques will correct me), presented from the start an immediate response: there is night and there is day. There is night that can be cold and day that eventually can be hot. Animals had to habituate themselves to these periods and internally create some kind of response. This kind of response evidently had an adaptive characteristic: the organism adapts to night, the organism adapts to day, the organism adapts to certain latitude, in certain latitudes day and night are practically alike (in the Equator level). But as we distance from the equator to the poles only occasionally, during equinox, will the days be the same. The animals have to adapt to this kind of thing: the animals that live in the vicinity of the poles, for example, may have a very long day, or a very short night. All this generated in animals the need to adapt to these environmental periods. This adaptation to environmental periods was, in the beginning, a physiologically adaptive answer, but with time, somehow (and I hope that in the discussion Menna-Barreto and Nelson Marques will correct me), and I don´t know exactly how, these rhythms became part of the animals themselves: even in the absence of environmental periods they continued to manifest. It is what we would call endogenous rhythm. Animals, in the course of evolution (I speak mostly of animals because I am a zoologist), became diurnal, crepuscular or nocturnal. Why did this happen? The discussion of the reason for this is very complex, it implies in the discussion of the evolution of morphological and physiological devices that made it possible for animals to have a nocturnal, crepuscular or diurnal life. But the rule in the periods, in these biological rhythms (I will limit my talk to biologic rhythms) is this correlation to geophysical conditioned periods and its study is better done when faced from a physiological or behavioral point of view, meaning the rhythm of an animal, the rhythmic activity of an animal, the value of days, the number of seasons, they are well measured by the study of a physiological or behavioral point of view. These rhythms that the animals present are different from other rhythms that are not related to environmental periods, for example, the cardiac rhythm, the breathing rhythm, which have nothing to do with environmental periods, or will only remotely or secondarily have something to do with these periods. Which are the components of rhythm? In a natural environment, rhythms result from two sources, and this is due to what I said previously: direct responses to the periodically floating environment or (and here is a concept that is very difficult to understand), an inherent tendency of the organisms to repeat physiological and behavioral forms and patterns in time. It is an inherent tendency, and as I said I am not a specialist, of the discussion that will take place here, people who are chronobiologists will explore the subject with more depth. As I said, the most important environmental factors are light, because there is alternation between day and night; temperature, because eventually, with seasons, temperature fluctuates and, in the same day, in the deserts, for example, the temperature can be abrasive during the day and almost zero at night, with no seasonal influence, meaning that the season did not change, this is typical of the region. I also said that the factors of lesser importance, at least apparently, are the subtle geophysical parameters, such as electromagnetism, locally generated electrical fields and such, which can influence in the imposition of a rhythm to a certain animal. What are the animal rhythms, the biological rhythms for? They have three purposes: to temporally regulate the phenomenons of the organism, capacitating them to maintain great physiological, forgive me, I mean adaptive states to face rhythmic environmental variations. Secondly, they serve to coordinate intraspecific activities, to regulate temporally the dynamic of ecosystems. In third place, the rhythms serve to also temporally order the independent rhythm of organs with interactive ends. What are the rhythms considered in biology? First of all, the rhythm of the solar day. My lecture, different from my colleagues who were highly philosophical in mathematics and astrophysics, my lecture is more grounded, and I feel you will understand much more of what I have to say then what they said, at least in my point of view. It is almost a class. Since I sensed that those present here were multidisciplinary, I imagined I could give a graduation level class, such as I give in the university courses. Forgive me, I do not mean to say you are not intelligent or cultured, just that you are of varied areas, which naturally forces me to sometimes deal with elementary things when you know the subject well. However, other rhythms are: circadian rhythm, geophysical dependent rhythms, rhythms related to the moon, annual rhythms and even sidereal rhythms. The animals exhibit rhythms of all these kinds. The most common rhythm, the most extensively studied has been the rhythm of the solar day. All the factors which condition the rhythm of the solar day in animals have twenty for hour periods. What is the decanted circadian rhythm? It comes from a Latin word, circadiem, around the day. It is an artificial rhythm, in the strict sense, this rhythm does not have a natural connotation, it is experimental, which means that when I force an animal to stay in permanent darkness this animal will lengthen or shorten his daily rhythm. Thus, he adjusts according to the day, either stretching or shortening the activity period, which originates the name circadiem or circadian. These circadian rhythms become what the English call free running, and which happen regardless of any other factor. Geophysical independent rhythms are answers to environmental variables, they are residual, subtle, uncontrolled. The physicist may be able to control these subtle variables, but it is very difficult for a biologist to consider, besides the alternation of day and night, the alternation of temperature, the alternation of environmental humidity, the alternation of hunting times of animals and other factors the organism is subjected to. Probably electromagnetism: in this case, the, rhythms may vary according to the local time, such as the time of the inclination of the Sun, for example. However, these rhythms, due to subtle geophysical factors, are answers that are generally masked by answers imposed by more obvious rhythms, meaning the solar day, those I mentioned before. Such rhythms, since they are more subtle, are of difficult experimental detection, but there are influences from these parameters in the imposition of a certain rhythm for the animal. Rhythms related to the moon: of course we all know the moon has a great influence, especially over the tides, and the people here have already spoken of this. The tides, high and low, have different heights. There are tides called the spring tide, and the tides called neap tides, the tides from the first quadrature of the crescent quarter and the second quadrature of the waning crescent. These tides influence the movement of the sea and there are animals that accompany the rhythm of these tides. There are studies from an Italian group from Papi&Pardi, for example, who study antipodes, which clearly exhibit this tide rhythm. The animals accompany the tide, rise as high as the tide, lower as low as the tide, and so forth. Regarding the annual rhythms, of course there are annual rhythms, even on the Equator, where one would suppose there are no annual rhythms, there are annual rhythms because on the equator there are drought and rainy periods and this implies in the imposition of rhythms to the animals. The harder rhythms, as I see it, are the called sidereal rhythms. This means that the organisms would also feel the movement of the celestial sphere. This is very subtle, and I know of only one experiment regarding this, done by Brown, when he studied how much oxygen potatoes consumed. This is interesting. He discovered, in eleven years of continued study on the oxygen consumption, that the average cycle varied according to the celestial sphere. Thus, there was a sidereal influence in the imposition of rhythm. Another curious rhythm is the rhythm characterized by a name that derives from an Athenian astronomer called Meton. It is the metonic cycle. It is a cycle which repeats itself every 18 to 18.6 years. It is the case of the moon, for example. The moon would reappear on the same day, at the same time, in cycles of 18 or 18.6 years. Is this true? As best as I have been informed, this is the metonic cycle. Very well, there are animals that spawn, for example, according to the appearance of the full moon. The most characteristic case studied by Caspers is that of a poliqueto which lives in the southern oceans and which, when the moon appears, the animals surface, they come from the deep and stay on the surface, there is spawning and females emit eggs, the males emit sperm and there is fecundation. The natives use this occasion to make a large collection of palolo, which is delicious to eat, and then there is a depredation of palolo in this occasion. But this is not the only animal with a metonic rhythm. There is a crinoid that is an echinoderm, it looks like a sea spider, a somewhat complicated animal. The crinoid also has this rhythm. They do not spawn every 18 years, but every 18 years they spawn when the moon appears. They synchronize with the appearance of the moon. This is an interesting rhythm. The rhythms are also of great importance in two phenomenons that happen with animals: one is what Americans call homecoming, coming back home. The animal knows how to return home, it's the case of the birds, we know the compass of the birds is the movement of the sun, and as far as we know the animals set their rhythm to the movement of the sun and can then return to where they came from, and this is an interesting relationship. Now, to finish, I would like to say two more words, because the subject is vast and I am only expositing issues for discussion. It is the issue of the biological clock. Is there a biological clock? I know Nelson Marques and Menna know infinitely more about this subject then I do, I will only introduce the issue for you. The maintenance of rhythmic patterns in the absence of environmental periods, and with relatively stable periods regarding temperature and the chemical nature of the environment, suggests the idea that there is an internal clock in the organism, capable of "keeping" time and measuring geophysical natural periods. Of course this clock needs to be activated on chemical and physiological basis. As far as I know, and they may correct me, an explanation has still not been found in terms of the chemical and physiological reactions which would explain the existence, the functioning of this hypothetical clock. The basic issue regarding clocks is this: if the clocks appeared, as I said in the beginning of my lecture, due to repeated responses to an environmental request, because somehow, through a mutation or previous adaptation animals developed biological clocks to the point of them being genetically transmittable? This is the issue. Is there a biological clock, an endogenous clock? Or does the endogenous clock not exist, and what exists is simply an exogenous clock. Meaning that what we call a self-rhythm, inherent to the animal, this inherent tendency to which I made reference, this tendency is, in reality, commanded by exogenous forces. The hypothesis of an internal clock, the endogenous clock, explains many "free course" rhythm proprieties, circadian proprieties, but many of these still happened due to, or are attributed to mysterious subtle geochemical and geophysical factors. Now, what are the evidences that an endogenous clock exists? Here I will align a series of evidences: the persistent rhythm in the absence of environmental periodicity; the rhythm is experimentally capable of dislocation; the rhythm has a phase that can be initiated by simple and brief stimuli; the rhythm can be delayed regarding phase by metabolic depressors; the rhythm can deviate from what is geophysicaly correlated; and finally, the rhythm persists in the east-west and west-east translocations. These are evidences of rhythm. Now, how to explain rhythm? As I said, my knowledge is rudimentary in this field, but there is a hypothesis in molecular biology, a hypothesis raised by researches Ehret and Trucco, that appeared in the Journal of Theoretical Biology, in 1967, number 15. Ehret and Trucco imagine that there are very long DNA segments, a cistronic complex, with a transcription rate in its extension, regulated by a set of events, and this way the system works like a clock. This is a scientific language, and only those "initiated" in this subject can comprehend its meaning. This involves transcription and other knowledge. But there is another way to discover if there is a clock, it is a somewhat theoretical manner, it is done with models, so to speak. The endogenous clock presumes the existence of an oscillating mechanism, the oscillator. Thus, the theorists of the problem make oscillating systems and then study biorhythms and when one biorhythm presents a difficulty, they see if this difficulty conforms to the clock's prediction. This would happen regarding the endogenous clock. Thus, the endogenous clock has many facets, many supporters and is correlated to the called exogenous clock. The exogenous clock would evidently be the one that does not have an autonomous rhythmic capacity and explains the properties of rhythm as dependent on continuous input, the input of environmental rhythmic information. I said all this quickly and in a rush because I thought there wasn't enough time, and I hope my lecture can be of some use.