Scientific and Religious Controversies on Beginning of Human Life

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One of the most controversial topics in modern bioethics, science, and philosophy is the beginning of individual human life. In the seemingly endless debate, strongly stimulated by recent technologic advances in human reproduction, a synthesis between scientific data and hypothesis, philosophical thought, and issues of humanities has become a necessity to deal with ethical, juridical, and social problems. Furthermore, in this field there is a temptation to ask science to choose between opinions and beliefs, which neutralize one another. The question of when human life begins requires the essential aid of different forms of knowledge. Here we become involved in the juncture between science and religion, which needs to be carefully explored.

Modern bioethics and science are strongly concerned for the respect of human life at both ends of its existence (birth and death), but other sciences (e.g., philosophy, technology, psychology, sociology, law, and politics) consider the beginning of human life according to different points of view. However, bioethical topics like this one cannot be treated from only one perspective (e.g., biological, philosophical, or religious) because conclusions might be not good enough or reductive. This reality should be regarded in all its richness: an embryo gives a biologist and a geneticist substance for consideration, but because we are talking about the beginning of human life, it requires philosophical–anthropological consideration and confrontation with theology; in its protection we have to include ethics and law. In experiencing and investigating social behavior, other disciplines, such as the history of medicine and sociology, have to be included.

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It is hard to answer the question when human life should be legally protected. At the time of conception? At the time of implantation? At the time of birth? In all countries (except Ireland and Liechtenstein), juridical considerations are based on Roman law. Roman civil law says that the fetus has right when it is born or if it is born-nasciturus.

Few countries agree with definition of beginning of human personality at the time of conception. The majority does not grant legal status to the human embryo in vitro (i.e., during the 14 days after fertilization). Thus, even in the absence of legal rights, there is no denying that the embryo constitutes the beginning of human life, a member of the human family. Therefore, whatever the attitude, every country has to examine which practices are compatible with the respect of that dignity and the security of human genetic material.

The question when a human life begins and how to define it could be answered only through the inner-connecting pathways of history, philosophy, medical science, and religion. It has not been easy to determine where to draw the fine line between the competence of science and metaphysics in this delicate philosophical field. To a large extent, the drawing of this line depends on one's fundamental philosophical outlook. The point at which human life begins will always be seen differently by different individuals, groups, cultures, and religious faiths. In democracy there are always at least two sides, and the center holds only when the majority realizes that without a minority democracy itself is lost. The minority in turn must realize its best chance lies in persuasion by reason and thoughtfulness rather than fanaticism.

In recent years, we have noticed robust increase of interest in the relationship between science and religion worldwide. In the past, the abovementioned, more or less autonomous intellectual activities often tried to dominate one over another, or they ignored each other. Only in recent times, most scientists and many theologians accept the view that scientific and religious "truths" are complementary and thus only methodologically independent. Today, science and religion are an important factor in the life of the people, the country, and the world. Science along with religion is the greatest gift the almighty granted on us.

Anticipating the future relations between science and technology, we can only extrapolate and wonder. In this century, we human beings have come to know who we are and where we are in ways unprecedented in all past millennia. We know the size, age, and extent of our universe; we know the deep evolutionary history of our planet and ourselves as part of this story. These facts of science have required integration into our classical religious worldviews; and these blending of theory and principle in science and religion will continue. In this century, we human beings have gained, through science and technology, more power than ever before to affect, for better or worse, our own well-being, that of the human and natural worlds, and even planetary history. The fate of the Earth, the fate of all who dwell thereon, depends, in the next century, on the responsible use of that power. Everything depends on how we join science, ethics, and religion in practice [1].

Modern science is not interested in the nature, but what we can say about nature; one does not invent occurrences yet it interprets it. Science differs from religion in

a way that its truth can and must be experimentally verified and its methodological knowledge can be learned. Religion is dominated by irrational moment and science by rational moment. Intellectual knowledge in science is expressed quantitatively, in the form of mathematical formulas and equations, but in religion qualitatively in the form of metaphors/abstractions. Technologies as practical expression of science on the other hand worship as practical expression of theology, and society of laymen, as the basis of democracy, today represent the pragmatic Western system of real capitalism. Today more often than ever, a dramatic development of technology opens a range of possibilities, which are all generated by science, but often aren't sufficiently analyzed and all the alternatives and consequences aren't understood. Most of the alternatives and consequences are not even possible to be observed and understood, and they remain exclusively in the domain of science and technology. Our life is far richer than it can be described only by science, and therefore the views of the great religions certainly must be taken in consideration.

At present, for instance, there is more dialogue and integration in physics, ample conflict, and considerable independence between biology and religion. Whether that trend will continue depends partly on discoveries as yet unknown in physics, astronomy, and molecular and evolutionary biology.

Global leadership in science and technology has not translated into leadership in infant health, life expectancy, rates of literacy, equality of opportunity, productivity of workers, or efficiency of resource consumption. Neither has it overcome failing education systems, decaying cities, environmental degradation, unaffordable health care, and the largest national debt in history. Basic human needs—elemental needs—are intrinsically different from other material needs because they can be satisfied. Other needs appear to be insatiable, as the consumption patterns of the United States clearly demonstrate. Once basic human needs are met, satisfaction with our lives cannot be said to depend on the amount of things we acquire, use, and consume. More technology-based economic growth is not necessary to satisfy humanity's elemental needs, nor does more growth quench our thirst for consumption. In terms of the social contract, we justify more growth because it is supposedly the most efficient way to spread economic opportunity and social well-being. I am suggesting that this reasoning is simplistic and often specious [2].

Despite that, there are still many unresolved issues which have not reached full agreement; however, public discussion can never solve all the problems and bring satisfaction to all. It should be directed toward the truth, even if it eventually reaches only compromise.

Today, there is a great tendency from upper level for another dialogue between science and religion, which existed since the very beginnings of our culture. Religion existed before science, but science is not an extension of religion. Each of them must keep their principles, their different interpretations, and their own conclusions. Although different, both are components of a common culture of humanity.

One of the most controversial topics in modern bioethics, science, and philosophy is the beginning of individual human life. In the seemingly endless debate, strongly stimulated by recent technologic advances in human reproduction, a synthesis between scientific data and hypothesis, philosophical thought, and issues of

humanities has become necessary to deal with ethical, juridical, and social problems [3]. Furthermore, in this field, there is a temptation to ask science to choose between opinions and beliefs that tend to neutralize one another. Indeed, the question of when human life begins requires the essential aid of different forms of knowledge. Here we become involved in the juncture between science and religion, which needs to be carefully explored [4].

Obviously, the beginning of human life is seen differently by different individuals, groups, cultures, and religions. Fundamental to productive debate and reconciliation between minority and majority groups is an understanding of the ill-defined concept of "the beginning of human life" [5].

Entering this field, scientists have been remiss in failing to translate science into the terms that allow mankind to share their excitement of discovering life before birth. Regardless of the remarkable scientific development, curiosity, and speculations dating back to Hippocrates, life before birth still remains a big secret. Different kinds of intellectuals involved themselves in trying to contribute to the solution of the human life puzzle. They are led by the idea that each newborn child will only reach its full potential if its development in utero is free from any adverse influence, providing the best possible environment for the embryo/fetus. Considering the embryo/fetus, it should be always kept in mind the amazing aspect of these parts of human life in which the pregnant woman and the embryo/fetus, although locked in the most intimate of relationships, are at all times two separate individuals. Accepting the embryo/fetus as a person opens a new set of questions about its personality and human rights.

The Definition of Life

Proper answers to the question of how to define human life are complicated. Nowadays, dilemmas consider the respect of human life from the birth to death involving not just biology, but other sciences also. Philosophy, theology, psychology, sociology, law, and politics evaluate this topic from different point of views. Integration of all could result in a useful answer.

Some authors say that life as such does not exist—no one has ever seen it. Szent-Gyorgy says that the noun "life" has no significance because there is no such thing as "life." Le Dantez holds that the expression "to live" is too general and that it is better to say a dog "dogs" or a fish "fishes" than a dog or a fish lives [6].

When defining life, it should be considered not just as it is today, but as it might have been in its primordial form and as it will be in the future. All present forms of life appear as something completely new. Life, then, is transferred and not conceived in each new generation. Furthermore, the phenomenon of life has existed on Earth for approximately 3.5 billion years. Consequently, although the genome of a new embryo is unique, the make-up of an embryo is not new. If life is observed through the cell, then every life (and human also) is considered as a continuum. Human cells and mankind have existed on Earth continuously since the appearance of the first man. However, if the definition

refers to a single human being or the present population, the statement that "human life is a continuum" is not acceptable [7, 8].

Life, in a true sense of the word, begins when the chemical matter gives rise, in a specific way, to an autonomous, self-regulating, and self-reproducing system. Life is connected with a living being, and it creates its own system as an indivisible whole—it forms its individuality. One of the most important characteristics of living beings is reproduction. Reproduction is a means of creating new life by transferring forms of an old one into newly formed human being. Therefore, variability, individual development, and harmony characterize human beings. Individuality is the most essential characteristic of human beings consisting of new life, but also all human life forms through evolution, characterized by phenotype, behavior, and the capability to recognize and adapt. Human embryo and fetus gradually develop into these characteristics.

"Human life" poses a semantic problem. The placenta is "human life," as is every individual cell or organ of the human body, but "human life" is clearly not equivalent to "human being." It is, therefore, mandatory to differentiate between organic or vegetative human life and "potential personal human life." The latter term allows various groups to identify a point of the continuum between abortion and birth to which they can ascribe appropriate values and rights [5].

Although we should not forget that in the same way today's research is tomorrow's benefit [6], concerning human life, conclusions should not be treated one-sidedly from one perspective. This reality should be regarded in all its richness: the embryo gives the biologist and geneticist substance for consideration, but talking about the beginning of a human life requires philosophical/anthropological consideration, as well as theological and social sciences. In its protection, we have to include ethics and law. This approach leads to the conclusion that it is necessary to reject reductionism as well as integrism and to find a "golden middle" between these two methodologies [3].

What Does Biology Say?

Biology characterizes human beings by the dynamics of the system and its self-control (homeostasis), excitability (response to stimuli of different nature and origins), self-reproducibility, the heredity of the characters, and the evolutionary trend [3]. For biologists, it is important to specify which form of life phenomena we are referring to: cell, organism population, or species. The basic level of organization and the simplest form of life is the cell. Biologically speaking, human cellular life never stops, or if it did, the extinction of the human species would result and is passed on from one generation to another. Human individual organismic life is defined within its life cycle, which is temporarily limited, i.e., it has a beginning and an end [9]. It is obvious that life is a highly dynamic phenomenon that could be described and explained through the careful study of life processes and interactions by interdisciplinary approach. In human spermatozoa and oocyte are two essential cells involved in creating human life. It is clear that biologists are most qualified to

render judgment on the structure and function of cells. To quote Scarpelli [10], the very broad scope of biological science (from molecular to behavioral biology and from unicellular to multisystem forms) brings with it the justifiable understanding that the biological scientist knows and is able to define the state of being alive or "life." If not, the science fails.

The biological scientist, who may specialize within one or another domain of the broad scope, has particular and definitive knowledge and understanding of the living individual that is his specialty. If not, disorder will rise above failure.

Understanding of the beginning of human life and development of the embryo/fetus could provide definitive resolution. However, with the recent possibility of visualizing early human development virtually from conception, perinatologists should be those who by study, training, practice, and research are singularly qualified [11].

While science provides us data about physical development of the human being, it does not provide information about its personality and personhood. These are philosophical, rather than scientific, topics.

Human Embryogenesis

Only proper understanding of the process of human embryogenesis enables answering scientifically the question of when the life cycle of a human individual starts. Therefore, in the following text, the main steps of the human developmental process are going to be briefly described, primarily during the first 15 days following fertilization.

A human being originates from two living cells, the oocyte and the spermatozoon, transmitting the torch of life to the next generation. The oocyte is a cell approximately 120 μm in diameter with a thick membrane, known as the zona pellucida. The spermatozoon moves, using the flagellum or tail, and the total length of the spermatozoon including the tail is 60 μm [12].

After syngamy, the zygote undergoes mitotic cell division as it moves down the fallopian tube toward the uterus. A series of mitotic divisions then leads to the development of the preembryo. The newly divided cells are called blastomeres. From 1 to 3 days after syngamy, there is a division into two cells and then four cells. Blastomeres form cellular aggregates of distinct, totipotent, undifferentiated cells that, during several early cell divisions, retain the capacity to develop independently into normal preembryos. As the blastocyst is in the process of attaching to the uterine wall, the cells increase in number and organize into two layers of cells. Implantation progresses as the outer cell layer of the blastocyst, the trophectoderm, invades the uterine wall and erodes blood vessels and glands. Having begun 5 or more days after fertilization with the attachment of the blastocyst to the endometrial lining of the uterus, implantation is completed when the blastocyst is fully embedded in the endometrium

several days later. Even during these 5–6 days, modern medicine introduces the possibility of making preimplantation genetic diagnosis.

However, at this time, these cells are not yet totally differentiated in terms of their determination to specific cells or organs of the embryo. The term preembryo, then, includes the developmental stages from the first cell division of the zygote through the morula and the blastocyst. By approximately the 14th day after the end of the process of fertilization, all cells, depending on their position, will have become parts of the placenta and membranes or the embryo. The embryo stage, therefore, begins approximately 16 days after the beginning of the fertilization process and continues until the end of 8 weeks after fertilization, when organogenesis is complete [13].

The preembryo is the structure that exists from the end of the process of fertilization until the appearance of a single primitive streak. Until the completion of implantation, the preembryo is capable of dividing into multiple entities, but does not contain enough genetic information to develop into an embryo; it lacks of genetic material from maternal mitochondria and of maternal and parental genetic messages in the form of messenger RNA or proteins. Therefore, during the preembryonic period, it has not yet been determined with certainty that a biological individual will result or would be one or more (identical twins forming), so that the assignment of the full rights of an individual human person is inconsistent with biological reality.

One conclusion from this is that the preembryo requires the establishment of special rules in the society: it cannot claim absolute protection based on claims of personhood; although meriting respect, it does not have the same moral value that a human person has. Today, one largely accepted opinion is that until the 14th day from fertilization or at least, until implantation—the human embryo may not be considered, from the ontological point of view, as an individual.

Genetic uniqueness and singleness coincide only after implantation and restriction have completed, which is about 3 weeks after fertilization. Until that period, the zygote and its sequelae are in a fluid process, are not physical individual, and, therefore, cannot be a person.

It is well-known that high percentages of oocytes which have been penetrated never proceed on to further development and that many oocytes which do are thwarted so early in their development that their presence is not even recognized. It is suggested that 30% of conceptions detected by positive reactions to human chorionic gonadotropin (HCG) tests abort spontaneously before these pregnancies are clinically verified.

The newly conceived preembryo presents itself as a biologically defined reality. However, the status of the preembryo as an individual remains a great mystery. In the present scientific scene especially with the progress of ultrasound technologies, prenatal psychology and therapeutics opened a window into prenatal life of embryo and fetus confirming the evidence that the embryo/fetus is a true subject itself [14, 15].

Personality

Defining personality is very complex. There is still no clear definition of personality. One dictionary offers "what constitutes an individual as distinct person," but does not define what the "what" is. Another dictionary asserts "the state of existing as a thinking intelligent being." This definition might lead to the inference that personality increases pro rata with intelligence or that some people may not have a personality at all if we followed Bertrand Russell's dictum that "most people would rather die than think and many, in fact, do!" Kenneth Stallworthy's *Manual of Psychiatry* is more help with the definition that "personality is the individual as a whole with everything about him which makes him different from other people," because we can certainly distinguish fetuses from each other and from other people. With the next sentence—"personality is determined by what is born in the individual in the first place and by everything which subsequently happens to him in the second"—we are really in the field [3, 5].

Viewpoints on the nature of "personhood" and what it means ethically and legally vary widely. In his proposed Life Protection Act, Sass acknowledges that a fetus with formed synapses is not a "person" in the usual sense of the word, connoting consciousness and self-consciousness [16]. Veatch sees the problem as defining the life that has full moral standing [17], while Knutson [18] has noted that "those who employ spiritual or religious definitions of when life begins tend to place the beginning of life earlier than those who employ psychological, sociological, or cultural definitions."

Led by the truism, "No insignificant person was ever born," human beings should be valued from birth to natural death. It is hard to establish proper values and exact definitions. This becomes especially problematic when prenatal life is considered. The above stated truism opens an important question: "Is the person-unborn a person in the first place and, if so, is the person-unborn a 'significant' person?" [3].

Let us evaluate further present controversies. There is no doubt that the embryo and fetus in utero are biologically human individuals prior to birth. The child who is born is the same developing human individual that was in the mother's womb. Birth alone cannot confer natural personhood or human individuality. This is confirmed by preterm deliveries of babies who are as truly human and almost as viable as those whose gestation goes to full term. All the known evidence supports the human fetus being a true ontological human individual and consequently a human person in fact, if not in law. A human person cannot begin before the appropriate brain structures are developed that are capable of sustaining awareness. The same applies to a grossly malformed fetus. It would still be a human individual even if its human nature was not perfect or its functions quite normal. Nobody questions the humanity of a Down's syndrome fetus or child. A fetus or child with severe open spina bifida is not less of a human being. The same should be said for the live anencephalic fetus or infant with only brainstem functions. It is a human individual even if it lacks a complete brain and usually survives birth by only a few hours or a day.

"Person" and "personhood" are the legally operational terms in the United States and many other countries. Alternatively, "person" and "personhood" are replaced by

terms such as "viable outside the uterus," "a woman's right to privacy," and "a woman's right to choose." In each case, viable, privacy, and choice, the life-support provider may legally order transfer of the dependent individual into a morbid environment. For this group, dilemma (which includes the stem cell, abortion, and cloning debates) is abated, but not resolved [5].

Human society created several standards in defining "person" or "human being" based on what is familiar and easy recognizable [3]. For example, a human speaks, understands, and laughs. Absence of these characteristics (mutism, autism, and stoicism) does not disqualify. To the contrary, the conclusion is that the characteristics we have come to associate with being a person may not be applicable to each individual person. Therefore, it is necessary to establish criteria for a definition of "person" in society and in time. Some prominent Italian professors [14] committed themselves to caring for the embryo in such a way, giving the same dignity to every patient, and the human conditions to grow and develop, to educate others inside and outside the specialty, and to carry out research involving all the components of society.

Embryo as a Patient

Bioethical Aspects

The idea of the embryo/fetus as a miniaturized infant or adult is true to the extent that the embryonic/fetal physiologist must be able to apply knowledge of every system after birth, yet quite untrue in failing to recognize the many ways in which life before birth differs fundamentally from life after birth [6]. The newly conceived form presents itself as the biologically defined reality: it is an individual that is completely human in development that autonomously, moment by moment without any discontinuity, actualizes its proper form in order to realize through intrinsic activity, a design present in its own genome [14]. The embryo as a patient is best understood as the subset of the concept of the fetus as the patient. These two concepts opened a whole set of questions regarding ethical problems. The embryo as the patient is indivisible from its mother. However, balance is needed in protecting the interests of the embryo/fetus and the mother. One prominent approach to understanding the concept of the embryo/fetus as a patient has involved attempts to show whether or not the embryo/fetus has independent moral status or personhood [19–21]. Independent moral status for the fetus would mean that one or more of the characteristics possessed either in or of the embryo/fetus itself, and therefore independently of the pregnant woman or any other factor, generate and therefore ground obligations to the embryo/fetus on the part of the pregnant woman and her physician.

A wide range of intrinsic characteristics has been considered for this role, e.g., moment of conception, implantation, central nervous system development, quickening, and the moment of birth [22]. Given the variability of proposed characteristics, there are many views about when the embryo/fetus does or does not acquire independent moral status. Some take the view that the embryo/fetus possesses

independent moral status from the moment of conception or implantation. Others believe that the embryo/fetus acquires independent moral status in degrees, thus resulting in "graded" moral status. Still others hold, at least implicitly, that the embryo/fetus never has independent moral status so long as it is in utero [21].

Being a patient does not require that one possesses independent moral status [23]. Being a patient means that one can benefit from the application of the clinical skills of the physician [24]. Put more precisely, a human being without independent moral status is properly regarded as a patient when the following conditions are met: that a human being is presented to the physician for the purpose of applying clinical interventions that are reliably expected to be efficacious, in that they are reliably expected to result in a greater balance of goods over harms in the future of the human being in question [22]. In other words, an individual is considered a patient when a physician has beneficence-based ethical obligations to that individual.

To clarify the concept of the embryo/fetus as the patient, beneficence-based obligation is necessary to be provided. Beneficence-based obligations to the fetus and embryo exist when the fetus can later achieve independent moral status [24]. This leads to the conclusion that ethical significance of the unborn child is in direct link with the child to be born—the child, it can become.

Legal Status of the Embryo

When discussing law, it should be always kept in mind that medicine is international, but law is not. Before the era of Aristotle, who taught that human life begins when the fetus is formed, human life was considered to begin at birth. Prior to birth, the fetus was not an independent human being but, like an organ, part of the mother [25]. Thus the birth of a full-term infant has been used in the laws of various countries to signify the beginning of the human life that is to be protected.

Indeed, the status of the human embryo is not juridically defined and relies on the political, social, and religious influences in each country. Interestingly, nearly all countries of the Western world use the 12th week of pregnancy as the limit for legal abortion. It is not the end of the first trimester, which is 13.3 weeks, and there is no other particular biological event to justify this limit.

It is hard to answer the question when human life should be legally protected. At the time of conception? At the time of implantation? At the time of birth? In all countries (except Ireland and Liechtenstein), juridical considerations are based on Roman law. Roman civil law says that the fetus has rights when it is born or if it is born-nasciturus.

Few countries agree with the definition of the beginning of human personality at the time of conception. The majority does not grant legal status to the human embryo in vitro (i.e., during the 14 days after fertilization). Thus, even in the absence of legal rights, there is no denying that the embryo constitutes the beginning of human life, a member of the human family. Therefore, whatever the attitude, every country has to examine which practices are compatible with the respect of that dignity and the security of human genetic material [26].

Arguments for Beginning of Human Life and Human Person at Fertilization

The fundamental approaches of biomedical and social (secular) practice must begin with the understanding that the subject before birth is a person and that "personhood" is conferred by successful fertilization of the egg. To hide from this in silence or ignorance should be unacceptable to all, as stressed by Scarpelli [11].

The view that human life begins when sperm and eggs fuse to give rise to a single cell human zygote, whose genetic individuality and uniqueness remain unchanged during normal development, is widely supported. Because the zygote has the capacity to become an adult human individual, it is thought it must be one already. The same zygote organizes itself into an embryo, a fetus, a child, and an adult. By this account, the zygote is an actual human individual and not simply a potential one, in much the same way as an infant is an actual human person with potential to develop to maturity and not just a potential person. As Scarpelli pointed out, outside the realm of religious dogma, there has been no one whose existence can be traced back to any entity other than the fertilized egg. The biological line of existence of each individual, without exception, begins precisely when fertilization of the egg is successful [11].

The process of fertilization actually begins with conditioning of the spermatozoon in the male and female reproductive tracts. Thereafter, fertilization involves not only the egg itself, but also the various investments which surround the egg at the time it is released from the ovary follicle. Fertilization, therefore, is not an event, but a complex biochemical process requiring a minimum of 24 h to complete syngamy, that is, the formation of a diploid set of chromosomes. During this process, there is no commingling of maternal and paternal chromosomes within a single nuclear membrane (prezygote); after this process, the parental chromosome material is commingled (zygote).

Among the many other activities of this new cell, most important is the recognition of the new genome, which represents the principal information center for the development of the new human being and for all its further activities. For the better understanding of the very nature of the zygote, two main features are to be at least mentioned here. The first feature is that the zygote exists and operates from syngamy on as a being, ontologically one, and with a precise identity. The second feature is that the zygote is intrinsically oriented and determined to a definite development. Both identity and orientation are due essentially to the genetic information with which it is endowed. That is why many do believe that this cell represents the exact point in time and space where a new human individual organism initiates its own life cycle [3].

Arguments Against the Beginning of Human Life at Fertilization

Today, one largely accepted opinion is that until the 14th day from fertilization or at least until implantation, the human embryo may not be considered, from the ontological point of view, as an individual. There are at least five main reasons in favor of this opinion:

1. Before the formation of the embryonic disc, the embryo is "a mass of cells, genetically human," "a cluster of distinct individual cells," which are each "distinct ontological entities in simple contact with the others" [27]. The genetically unique, newly developed DNA, a genome, is not established until 48 h after sperm penetration. The ovum and sperm lie side by side for more than 48 h before they finally merge. In biological terms, this renders conception as a process that occurs overtime and not a specific point in time [5].
2. Until approximately the 14th day after fertilization, all that happens is simply a preparation of the protective and nutritional systems required for the future needs of the embryo. Only when the entity called embryonic disc is formed can the embryo develop into a fetus [28].
3. The monozygotic twins phenomenon or chimeras can occur. In fact, this seems to be the strongest reason why the embryo is denied the quality of individuality and as a proof that the zygote cannot be an ontologically human being. In approximately one-third of cases, the embryo divides at about the two cells stage, and in the other two-thirds, the inner cell mass divides within the blastocyst from day 38. Occasionally, the division takes place from day 8–12, but usually it is not complete, thereby forming conjoined identical twins or two-headed individuals. The chimera, resulting from the recombination of two individual to become one individuum (and detectable through genetic testing), provides another argument against the equivalence of conception and the beginning of human life: no individuum has died, yet one has ceased to exist.
4. Co-existence of the embryo with its mother is a necessary condition for an embryo belonging to the human species, and this condition can be obtained only at implantation [21]. However, there is evidence that development of a human embryo in vitro can continue well beyond the stage of implantation and that mouse embryos implanted under the male renal capsule can reach the fetal stage. It is also argued, or at least implied, that so many human embryos die before or after implantation that it would be lacking in realism to accept that the human individual begins before implantation.

   It is well-known that high percentages of oocytes which have been penetrated never proceed on to further development and that many oocytes, which do, are thwarted so early in their development that their presence is not even recognized. Up to 50% of ovulated eggs and zygotes recovered after operations were found so grossly abnormal that it would be very unlikely that they would result in viable pregnancies. It is also suggested that 30% of conceptions detected by positive reactions to human chorionic gonadotropin (HCG) tests abort spontaneously before these pregnancies are clinically verified. The scientific literature is not unanimous on the incidence of natural wastage prior to, and during, implantation in humans, varying from 15% to as much as 50%. The vast majority of these losses are due to chromosomal defects caused during gametogenesis and fertilization [29].

   Genetic uniqueness and singleness coincide only after implantation and restriction have completed, which is about 3 weeks after fertilization. Until that period, the zygote and its sequelae are in a fluid process and are not a physical

individual and therefore cannot be a person. Although in a set of twins, one individuum can disappear, genetic and individual identities are now more or less equivalent. Many eminent Catholic writers, among them the Australian priest Norman Ford, author of *When Did I Begin?*, consider implantation to mark the beginning of human life; they maintain that the preembryo has only intrinsic potential and must be protected only from the time of implantation [30].

5. The product of fertilization may be a tumor, a hydatidiform mole, or chorioepithelioma. Though the mole is alive and of human origin, it is definitely not a human individual or human being. It lacks a true human nature from the start and has no natural potential to begin human development.

   A teratoma is another clear instance of cells developing abnormally that results from the product of fertilization, but which could not be considered to be a true human individual with a human nature. It has no potential to develop into an entire fetus or infant. Clearly, the fetus with the teratoma would be a human individual, but not the attached teratoma itself. Obviously, not all the living cells that develop from the conceptus, the early embryo, or the fetus form an integral part of a developing human individual [3].

Different Religious Teachings and Historical Aspects

The Catholic Church's teachings are clearly described in the Introduction Donum Vitae: "A human creature is to be respected and treated as a person from conception and therefore from that same time his (her) rights as a person must be recognized, among which in the first place is the invaluable right to life of each innocent human creature."

In 1997, the Third Assembly of the Pontifical Academy for Life was held in Vatican City. It has been concluded that "at the fusion of two gametes, a new real human individual initiates its own existence, or life cycle, during which—given all the necessary and sufficient conditions—it will autonomously realize all the potentialities with which he is intrinsically endowed." The embryo, therefore, from the time the gametes fuse, is a real human individual, not a potential human individual. It was even added that recent findings of human biological science recognize that in zygotes resulting from fertilization, the biological identity of a new human individual is already constituted [31, 32].

In Western Europe and in North and South America, these opinions are mostly based on Judeo-Christian theology; in Arabian Countries, in Africa, and in Asia prevail the influences of the Islamic and Buddhist religions. Although their approach to the beginning of human life is impressively similar, each of these religions has different attitudes to the problem of embryo research, infertility, and its therapy. In a fact, while the Jewish attitude toward infertility is expressed in the Talmud sayings and in the Bible (synthesized in the first commandment of God to Adam "Be fruitful and multiply"), the Christian point of view establishes no absolute right to parenthood. According to the Islamic views, attempts to cure infertility are not only permissible but also a duty.

Islamic teaching is based on prophet Mohammed description: "The creation of each of you in his mother's abdomen assumes a 'nufta' (male and female semen drops) for 40 days, then becomes 'alaga' for the same (duration), then a 'mudgha' (like a chewed piece of meat) for the same, then God sends an angel to it with instructions. The angel is ordered to write the Sustenance, life span, deeds and whether eventually his lot is happiness or misery, then to blow the Spirit into him" (Human developments as described in Khur'an and Sunnah; Moore, et al. In: Some evidence for the truth of Islam, 1981). The summary of this poetic and sacred description is as follows: soul breathing "ensoulment" occurs at 120 days of gestation from conception.

To make this religious principle applicable to the practice, the Islamic Jurisprudence Council wrote a Fatwa in 1990 that said: "Abortion is allowed in the first 120 days of conception if it is proven beyond doubt that the fetus is affected with a severe malformation that is not amenable to therapy, and if his life, after being born, will be a means of misery to both him and his family, and his parents agree" so that there is no difficulty either for the prenatal diagnosis or for the possible termination of pregnancy within the exposed limits.

Buddhism has imposed strict ethics on priests, but it has relatively lenient attitudes toward lay people, so if medical treatment for infertility is available, people should make use of it.

For about 2000 years, the opinions of Aristotle, the great Greek philosopher and naturalist, on the beginning of the human being were commonly held. He argued that the male semen had a special power residing in it, pneuma, to transform the menstrual blood, first into a living being with a vegetative soul after 7 days and subsequently into one with a sensitive soul 40 days after contact with the male semen [33].

Aquinas adopted Aristotle's theory, but specified that rational ensoulment took place through the creative act of God to transform the living creature into a human being once it had acquired a sensitive soul. The first conception took place over 7 days, while the second conception, or complete formation of the living individual with a complete human nature, lasted 40 days [34].

Hippocrates believed that entrance of the soul into the male embryo occurred on the 30th day of intrauterine life. It entered into the female embryo on the 40th day. Actually, this idea was a considerable improvement on the scheme found in the Book of Leviticus, where it is suggested that the soul does not enter the female until 40 days after the conception [35].

In short, the rational soul enables the matter to become a human being, an animated body, an embodied soul, a human person.

Harvey's experiments with deer in 1633 proved Aristotle's theory of human reproduction wrong, without himself finding a satisfactory explanation of human conception. After modern scientists discovered the process of fertilization, most people took for granted that human beings, complete with a rational soul, began once fertilization had taken place.

It is clear that the answer to the question "When has the human being actually come to life?" could only be given by combining the cognition of different religions, philosophies, and various biological scientific disciplines. There is a very fine

line between the competence of science and the one of metaphysics, and it greatly depends on the individual's philosophical principles. Those two, more or less autonomous intellectual disciplines, have very often tried dominating one another or ignoring each other. It is only recently that the majority of scientists and some theologians have come to realize that the separate meanings of scientific and religious "truths" complement each other, thus representing methodologically independent entities. Current science is not interested in what nature is, but in the facts that could be stated regarding it, thus trying to explain the term, rather than inventing it. The main difference between science and religion can be seen in the fact that scientific "truths," unlike religious postulates, can and must be experimentally verified, and the methods of scientific cognition can be easily explained and learnt. Whereas religion favors irrationality, science prefers an entirely rational approach to matters of importance. Intellectual cognition, when scientifically expressed, usually is in a form of mathematical formulas and presented quantitatively. Contrarily, religion tends to keep its truths in a form of metaphoric expressions, preferring qualitative. Today, there is a tendency, on a higher level, to reopen the dialogue between the science and religion, which was present at the very beginning of our culture. Religion had existed long before science came to life, but science is not to be thought of as a continuation of the religion. Each discipline should preserve its principles, its separate interpretations, and its own conclusions. In the end, both of them represent different components of the one and indivisible culture of mankind.

Clinical Controversies

There are some clinical controversies pertinent in any discussion of when life begins. Spermatozoa are living cells. They present evidence that they are living by their motility. They are equipped with an effective mechanism for movement in the form of a tail that beats under the control of the cytoplasmic droplets within the head. These living cells, which have been manufactured in the testes, are released into the environment provided by the male reproductive tract. They are not yet capable of fertilization. The spermatozoon must first come under the influence of the male reproductive tract, where it acquires the ability to function in fertilization. Even after ejaculation, it is capable of penetrating the egg, and it is modified further by exposure to the female reproductive tract, taking on the ability or capacity to fertilize. The decision must be made as to whether the spermatozoon is a being (i.e., living and human with the potential for continued life once fertilization has occurred); albeit in another form, it is entitled to the right of protection as a person. Those who deny right for life to the spermatozoon might argue that it is not a complete human cell chromosomally—it contains only the haploid number of chromosomes. Paradoxically, those who take that point of view would insist that an individual born with fewer or more chromosomes than normal is human and entitled to all the rights of "personhood." As Mastroianni stressed, the decision to base the definition of "human life" solely on the number of chromosomes in a given cell has far-reaching implications [36].

Furthermore, life has been defined as being terminated when brain activity ends. If we were to say that life begins when brain activity starts, we would be admitting that the definition of the beginning of life is dependent upon technology and not upon ethics or morality.

Some suggested that the beginning of human life requires the neural fusion of the periphery with the center, as well as sufficient development of the brain itself [37]. Brody formulated the so-called symmetry concept: if the death of a human being requires the death of the brain, the beginning of human life shall correspond with the beginning of the life of the brain, considered to be at day 32 pc [38]. However, Sass has correctly pointed out that fusion is not established anatomically without neurons which form synapses, which would be expected from embryological development at 70 days (8 weeks) pc [39].

In this light, let us take for example the accepted definition of birth, which some years ago was described as the complete expulsion of a fetus of 1000 g or 28 weeks of pregnancy. With advances in perinatal and neonatal intensive care, the line was drawn at 500 g, or approximately 22 weeks of gestation, some years later. This meant that a 20-week-old fetus was not born by definition, even if it was viable. This concept has changed. The same logic applies to a live fetus being accorded the term "life," if we use such definitions as the beginning of brain activity or ultrasonic proof of heartbeat and movement. The establishment of each of these parameters is shifted to an earlier stage year by year by improving technological refinements in electronic and ultrasonic equipment. This leads us to the conclusion that to follow this line of reasoning means to give life, birth, and viability definitions determined by technology. The more advanced the technology, the earlier life begins.

In any consideration of the beginning of human life, it helps to think about when life ends. Let us consider the following: a 2-week-old newborn is hospitalized with massive brain injury suffered in an automobile accident. Despite all measures, no electrical or other brain activity can be detected during the next 2 days, and the child is pronounced dead. Its body parts may survive after its death, as after the death of every person of whatever age. Hair and nails grow for days. Kidneys, heart, liver, and other organs may go on living for years if transplanted into another individual. Cells taken soon after death and cultured in a laboratory might live well beyond the 72 or more years this child might have lived, although the life of the infant has ended. The conclusion reached in this case that death of the brain means the end of life is generally accepted by physicians, courts, and the public [6].

Returning to the question of when life begins, it is true that the DNA of the fertilized egg has the information necessary to form an individual, but so does virtually every other cell in the body. Nobody would claim full rights for the living cells of the infant killed in the accident, although each has a complete library of DNA. Nor would they for thousands of living skin cells we lose every time we wash our hands and faces. Is there some stage in the development of the brain that is critical? Or is it the time at which the fetus can survive outside the womb, with or without the support of medical technology? Should we revert to a criterion used for many years, the time of quickening, when one can feel the fetus moving? These are questions still to be answered.

Visualization of Early Human Development

Significant advances have been made in recent years in visualizing and analyzing the earliest human development. Most of them have been done by introduction of three-dimensional static and color Doppler and 4D sonography. Many new parameters about early human development are now studied directly by new ultrasound techniques.

Considerable number of biochemical, morphological, and vascular changes occur within the follicle during the process of ovulation and luteinization, and most of them can be studied by transvaginal ultrasound with color Doppler and 3D facilities [40]. If the oocyte is fertilized, the embryo is transported into the uterus where under favorable hormonal and environmental conditions, it will implant and develop into a new and unique individual. The introduction of transvaginal color Doppler improved the recognition of blood vessels enabling detailed examination of small vessels such as arteries supplying preovulatory follicle, corpus luteum and endometrium [28].

Perifollicular vascularization can help in identification of follicles containing high-quality oocytes, with a high probability of recuperating, fertilizing, cleaving, and implanting, while 3D ultrasound enables accurate morphological inspection and detection of cumulus oophorus. Follicles without visualization of the cumulus by multiplanar imaging are not likely to contain fertilizable oocytes. This information is especially useful in patients undergoing ovulation induction.

Following ovulation, the corpus luteum is formed as the result of many structural, functional, and vascular changes in the former follicular wall. Color Doppler studies of the luteal blood flow velocities enable evaluation of the corpus luteum function in second phase of menstrual cycle and early pregnancy. When the placenta takes over the role of production of progesterone, the corpus luteum starts regressing.

After ovulation, there is a short period during which the endometrial receptivity is maximal. During these few days, a blastocyst can attach to the endometrium and provoke increased vascular permeability and vasodilatation at the implantation site. Trophoblast-produced proteolytic enzymes cause the penetration of the uterine mucosa and erode adjacent maternal capillaries. This results in formation of the intercommunicating lacunar network—the intervillous space of the placenta. A small intradecidual gestational sac can be visualized by transvaginal sonography between 32 and 34 days [41].

The secondary yolk sac is the earliest extraembryonic structure normally seen within the gestational sac in the beginning of the fifth gestational week. The yolk sac volume was found to increase from 5 to 10 weeks' gestation. When the yolk sac reaches its maximum volume at around 10 weeks, it has already started to degenerate, which can be indirectly proved by a significant reduction in visualization rates of the yolk sac vascularity [27]. Therefore, a combination of functional and volumetric studies by 3D power Doppler helps to identify some of the most important moments in early human development.

The embryonic heart begins beating on about day 22–23, accepting blood components from the yolk sac and pushing blood into the circulation. The embryonic blood begins circulating at the end of the 4th week of development.

The start of the embryo-chorionic circulation changes the source of nourishment to all intraembryonic tissues. The survival and further development of the embryo become dependent on the circulation of embryonic/fetal blood. If the embryo-chorionic circulation does not develop, or fails, the conceptus is aborted. The embryo cannot survive without the chorion (placenta), and the chorion will not survive without the embryo. Avascular degenerated chorionic villi constitute the hydatidiform mole.

Within the embryo, there are three distinct blood circulatory systems [12]

1. Vitelline circulation (from yolk sac to embryo).
2. Intraembryonic circulation.
3. Two umbilical arteries (from embryo to placenta-fetoplacental circulation).

It is possible to visualize and assess them virtually from conception [42–46].

At 5 weeks from the maternal side of placenta, it is possible to obtain simultaneous three-dimensional imaging of the developing intervillous circulation during the first trimester of pregnancy. Three-dimensional power Doppler reveals intensive vascular activity surrounding the chorionic shell starting from the first sonographic evidence of the developing pregnancy during the fifth week of gestation.

At 7 weeks, three-dimensional power Doppler images depict aortic and umbilical blood flow. Initial branches of umbilical vessels are visible at the placental umbilical insertion.

During the 8th–9th week, developing intestine is being herniated into the proximal umbilical cord.

At 9–10 weeks, herniation of the mid-gut is present. The arms with elbow and legs with knee are clearly visible, while feet can be seen approaching the midline.

At 11 weeks, three-dimensional power Doppler imaging allows visualization of the entire fetal and placental circulation.

During the 11th–12th week of pregnancy, development of the head and neck continues. Facial details such as nose, orbits, maxilla, and mandibles are often visible. Herniated mid-gut returns into the abdominal cavity.

New Possibilities for Studying Embryonic Movements and Behavior

The latest development of 3D and 4D sonography enables precise study of embryonic and fetal activity and behavior (Fig. 4.1) [47]. With four-dimensional ultrasound, movements of head, body, and all four limbs and extremities can be seen simultaneously in three dimensions [48]. Therefore, the earliest phases of the human

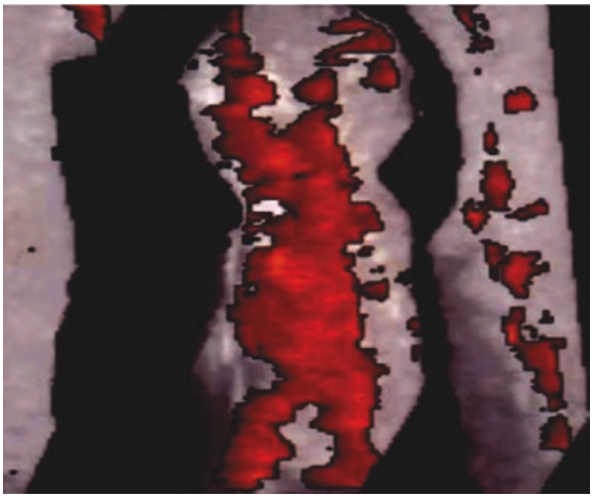

Fig. 4.1 Early triplets clearly visualized by three-dimensional sonography

anatomical and motor development can be visualized and studied simultaneously (Fig. 4.1). It is clear that neurologic development—early fetal motor activity and behavior—needs to be re-evaluated by this new technique [49–51]. Our group studied the development of the complexity of spontaneous embryonic and fetal movements [52]. With the advancing of the gestational age, the movements become more and more complex. The increase in the number of axodendritic and axosomatic synapses between 8 and 10, and again between 12 and 15 weeks [53], correlates with the periods of fetal movement differentiation and with the onset of general movements and complex activity patterns, such as swallowing, stretching, and yawning, seen easily by 4D technique. By 7–8 weeks of pregnancy, gross body movements appear. They consist of changing the position of the head toward the body. By 9–10 weeks of pregnancy, limb movements appear. They consist of changing the position of the extremities toward the body without the extension or flexion in the elbow and knee. At 10–12 weeks of pregnancy, complex limb movements appear. They consist of changes in the position of limb segments toward each other, such as extension and flexion in the elbow and knee.

Between 12 and 15 weeks of pregnancy, swallowing, stretching, and yawning activities appear. In addition to these activities, it is now feasible to study by 4D ultrasound a full range of facial expression including smiling, crying, and eyelid movement.

It is hoped that the new 4D technique will help us have a better understanding of both the somatic and motoric development of the early embryo. It will also enable the reliable study of fetal and even parental behavior [48].

There were recently a number of papers on new attractive techniques for visualization of early human development [54–66] (Figs. 4.2, 4.3 and 4.4).

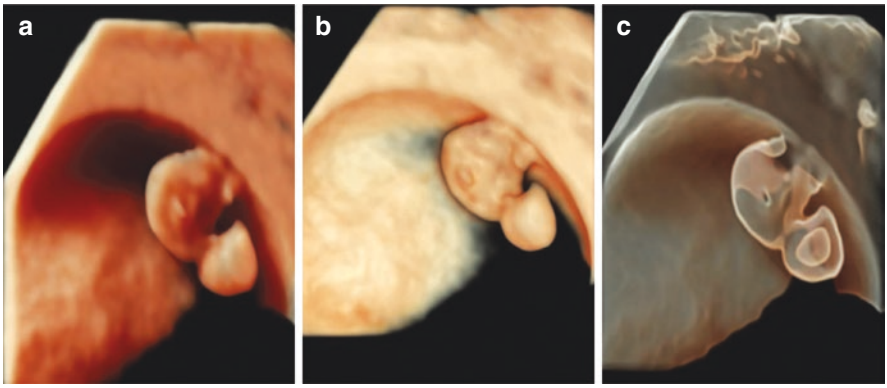

Fig. 4.2 (**a**–**c**) Six weeks HDlive silhouette images. (**a**) Conventional HDlive image of embryo and yolk sac. (**b**, **c**) With gradual increase of silhouette

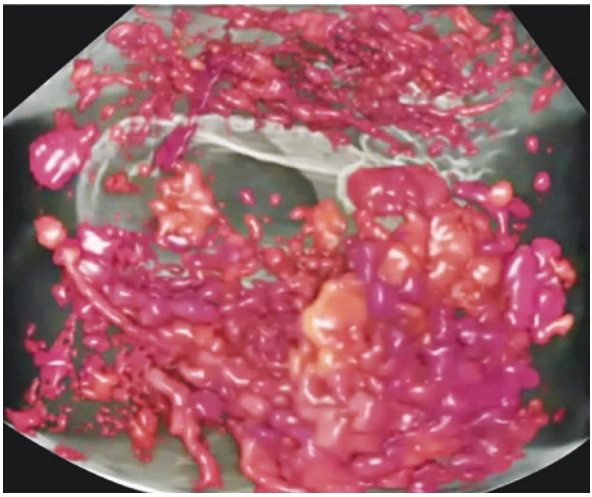

Fig. 4.3 Six weeks HDlive flow image of maternal–embryonal circulation

Fig. 4.4 Ten weeks HDlive silhouette image of embryo and amnion

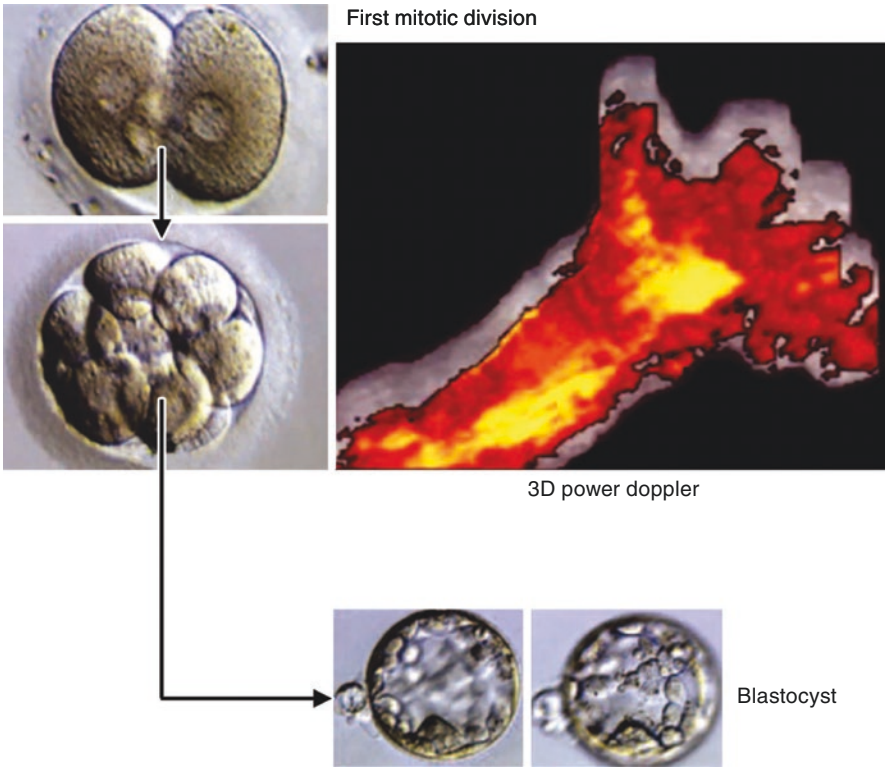

Fig. 4.5 Visualization of the patency of fallopian tube by three-dimensional power Doppler sonography, important for successful first mitotic division and transfer of early embryo to uterus

Conclusion

The question of when a human life begins and how to define it could be answered only through the interconnecting pathways of history, philosophy, medical science, and religion (Fig. 4.5). It has not been easy to determine where to draw the fine line between the competence of science and metaphysics in this delicate philosophical field. To a large extent, the drawing of this line depends on one's fundamental philosophical outlook. To quote Beller: "The point at which human life begins will always be seen differently by different individuals, groups, cultures, and religious faiths. In democracy, there are always at least two sides, and the center holds only when the majority realizes that without a minority, democracy itself is lost. The minority in turn must realize its best chance lies in persuasion by reason and thoughtfulness rather than fanaticism" [5].

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