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MATHEMATICS AS A LANGUAGE : VECTOR ANALYSIS OF A LIFE FROM CONCEPTION TO BIRTH

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Abstract

Mathematics is nothing but representation of natural phenomenon in its own language. There are mainly two branches of mathematics named as applied mathematics and pure mathematics. Both have their own importance in real and practical life. Pure mathematics is a mathematics done for its own sake and enriches itself by representing the phenomenon and rules of nature in its own language. It has also been described as “that part of mathematical activity that is done without explicit or immense consideration of direct application,” although what is ‘pure’ in one era often becomes applied later. On the other side, applied mathematics is application of mathematics to different branches of science. It tries to model, predict and explain things in the real world. In Von Neumann words, mathematics is "the relation of relationships." Today it is possible to go further, for a that branch of mathematics called Category Theory is not concerned with any particular field of mathematics but with the relationships between the different fields themselves! Mathematics at this level has the appearance of the purest and most rarefied thought. It is like a piece of music of such abstract perfection that the realization of a single performance would destroy its purity.

As the process of a child birth is a natural phenomenan, so it can be described in language of mathematics with the help of so called Category Theory. It is seen that there is one to one correspondence between the

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process of a life from conception to birth and notions of the vector space over a field. The paper purposes to present this correspondence between two distinct concepts of two distinct sciences viz. medical and mathematical.

Keywords : Vectors, Vector space, Vector subspace, Subsets of a vector space, Linear combination of vectors, Isomorphism between two vector spaces.

Intoduction

The structure of a vector space depends on the notion of (i) linear independence of vectors (ii) basis, and (iii) dimension which are then introduced. These structural constituents are now employed to describe vector subspace and sum or direct sum of subspaces. A vector **a** in the vector space $\mathbf{R}^n$ is an ordered set of n real numbers: $\mathbf{a} = (a_1, a_2, \ldots\ldots , a_n)$. The real number a_i is called the i-th component of **a**. Moreover, a vector is a quantity with magnitude and direction. These two definitions of a vector are equivalent. As Human body consists of cells and cells normally contain 46 distinctively human chromosomes, therefore, it can be treated to work as $\mathbf{R}^{46}$, a 46 dimensional space with each cell as its point with 46 coordinates (a_1, a_2, ……. , a_{46}), where a_i's (1<= i <=46) denote elements from the infinite field of chromosomes.

Vector Formation in Womb

Every human being begins life as a single cell, formed when father's sperm fertilises mother's egg. Fertilisation normally takes place along a path (mother's Fallopian tube) 's' in $\mathbf{R}^{46}$, a 46 dimensional space, which connects the uterus (womb) with the ovary. The uterus is the size and shape of a large pear: it is made of muscle and it stretches to allow the baby's growth throughout the months of pregnancy. A woman ordinarily has two tubes and two ovaries, one at each side of her uterus. Every month one of the ovaries in turn releases an egg (ovum) may be viewed as a variable point p whose locus coincides with the path 's' towards the womb cavity. If the egg is not fertilised within 12 hours or so of being released, it dies; it cannot develop further. But if the woman has sexual intercourse during the days of her monthly cycle just before or at the time when an egg has been released from the ovary, then a sequence $<x_n>$ of

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mortal particles that may be viewed as points mathematically (sperm cells released by her partner) may approaches to the path 's' and one may coincide with the point p . When fertilisation is completed and the point p and a point from the sequence $<x_n>$ say x_k have combined, a new being comes into existence called zygote may be viewed as a vector as it is due to direction of sperm cells towards ovum and has a magnitude of 0.14mm. It is capable of further development. Because the parents are human - belonging to the species Homo sapiens - the new being is also human. Fertilisation (by which we mean conception) marks the beginning of the human lifespan. Chromosomes pass hereditary features from parents to offspring. Different species have varying numbers of chromosomes per cell: for example, a mouse has 40 while a cat has 38 i.e., a mouse and a cat may be considered to work as $\mathbf{R}^{40}$, a 40 dimensional space and $\mathbf{R}^{38}$, a 38 dimensional space respectively. Human body cells normally contain 46 distinctively human chromosomes. But an egg represented by point p and a sperm cell represented by x_k contain only 23 chromosomes each, have to allow for their adding together at fertilization. Therefore, p has the coordinates $(a_1, 0, a_3, 0, \ldots\ldots , a_{45}, 0)$ while the x_k has coordinates $(0, a_2, 0, a_4, \ldots\ldots , 0, a_{46})$ or vice versa. These two points sperm and ovum are termed gametes (from a Greek word for "marriage partners"). When they "marry" they make one completely new cell - the human zygote or conceptus – with 46 chromosomes carrying a fresh, unique combination of genes as

$(a_1, 0, a_3, 0, \ldots\ldots , a_{45}, 0) + (0, a_2, 0, a_4, \ldots\ldots , 0, a_{46}) = (a_1, a_2, a_3, a_4, \ldots\ldots , a_{45}, a_{46})$.

Since characteristics come from both parents the zygote is never the same as, or part of, the mother, but is a genetically distinct individual. The colouring of hair, skin and eyes, the sex of the new human being, and factors influencing height and build, are determined at fertilisation by information on the DNA.

A baby's sex organ is determined at fertilisation. A chromosome from the father's sperm determines whether the child is male or female. If a sperm cell x_k has cordinates $(0, a_2, 0, a_4, \ldots\ldots , 0, X, \ldots\ldots , 0, a_{46})$ the baby is a girl and the vector zygote has coordinates

$(a_1, 0, a_3, 0, \ldots\ldots , X, 0, \ldots\ldots , a_{45}, 0) + (0, a_2, 0, a_4, \ldots\ldots , 0, X, \ldots\ldots , 0, a_{46})$

$= (a_1, a_2, a_3, a_4, \ldots\ldots , X, X, \ldots\ldots , a_{45}, a_{46})$.

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If a sperm cell x_k has cordinates $(0, a_2, 0, a_4, \ldots\ldots, 0, Y, \ldots\ldots, 0, a_{46})$ the baby is a boy and the vector zygote has coordinates

$(a_1, 0, a_3, 0, \ldots\ldots, X, 0, \ldots\ldots, a_{45}, 0) + (0, a_2, 0, a_4, \ldots\ldots, 0, Y, \ldots\ldots, 0, a_{46})$

$= (a_1, a_2, a_3, a_4, \ldots\ldots, X, Y, \ldots\ldots, a_{45}, a_{46})$.

Actually in human beings out of 46 normal chromosomes 44 are autosomes and 2 are sex chromosomes X and Y which determine the sex of a baby. They make an organism male or female. Whether the individual will be male (XY) or female (XX) depends on the chromosome the sperm carries. If the sperm that fertilizes the egg carries X chromosome the offspring will be female (XX) and if the sperm carries the Y chromosome the offspring will be male (XY) as defined above. Therefore, it is the male who is responsible for determining the sex of a baby. But still today there are cases of domestic violence like torturing a woman by her inlaws for producing a female child.

Sometimes two points p and q (eggs) travel along the path 's' and coincide with two distinct terms of sequence $<x_n>$ say x_k and x_t . This results in two distinct vectors (zygotes) which have different magnitude and direction because their coordinates (genes) form from two distinct points (eggs) and two distict terms of sequence $<x_n>$ (sperm cells). Rarely, the system of vectors with an outline (embryo) resolved into two and both its components develop separately, as identical twins, similar in direction and magnitude (appearance).

Reduction of a Vector into an Infinite System of Vectors to Implant a Baby

After fertilization the vector termed as zygote changes its direction towards the womb and it resolves into two. As the components of vector zygote are also a vector, therefore, the multiplication of a vector by a scalar take place with these two components. The product of a vector **a** by any scalar k is a vector k**a** (i) whose magnitude is equal to the magnitude multiplied by |k|; (ii) whose direction is that of **a** if k >= 0 but is opposite of **a** if k < 0. Here the nutrients work as scalars to increase the magnitude of the components of vector zygote. (Here one may confuse how nutrients can work as a scalar in the field of chromosomes. It should be noted that Chemical components of chromosome are DNA, RNA(nucleic acid), and proteins.

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There is in addition, calcium, which seems to be associated with the DNA. Calcium is important in binding sections of the chromosome together. DNA, RNA(nucleic acid), and proteins all contribute to the chromosomal mass. Further nucleus consists of enzymes and inorganic contents like salts of calcium, potassium, magnesium, phosphorus, iron and zinc. Thus the substances required for body growth are present in chromosomes) Now these are two new vectors rather than the components of the vector zygote. Then these two vectors double to four, four to eight, eight to sixteen and so on by the same process. Now we have an infinite system of vectors, looks like a berry it is called morula (Latin for mulberry). The journey along the path 's' continues for about four days. The scalar multiplication continues. This system of vectors with different magnitude and direction is referred as blastocyst. Meanwhile the womb is forming an outline within which morula is to be placed for further development. This begins 6 days after fertilization and is completed within the next 7 days. The infinite system of vetors morula with an outline in the womb is termed as an embryo. If fertilization has not taken place, the lining of the womb comes away at the end of the monthly cycle as the woman's menstrual period. But once implantation occurs, the embryo sends out a hormonal signal which prevents the mother's period. This is the first indication of implantation.

Conversion of an Infinite System of Vectors into a Subspace to Make Baby a Perfect Human

The system of vectors termed as an embryo can be categorized into three distinct parts, the vectors with larger magnitude, the vectors with medium magnitude and the vectors with smaller magnitude. Now dot product of vectors take place in this infinite system of vectors to form coordinates of different vectors (cells) to form components of distinct vectors that will form the different parts of our body. The dot product of two vectors **a** and **b**, denoted by **a**.**b** is defined to be the scalar obtained by multiplying corresponding components and adding the resulting products. The members of system of vectors with larger magnitude form coordinates for component of complex vectors such as the brain and nerves and the simple vectors such as hair and tooth enamel. The members of system of vectors with medium magnitude form coordinates for component of vectors such as bones, muscles blood vessels and the hurt as well as parts of the lungs. The members of system of vectors with smaller magnitude form coordinates for

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component of vectors such as liver, intestines, urinary tract and the other parts of the lungs. There exist two vectors with largest and smallest magnitude in opposite direction in the system of vectors defined as embryo that cross the outline of the embryo: one will be the head and the other will be the sex organ of the baby.

Around the time the embryo is six weeks old all the coordinates find their position to form component of distinct vectors. A resultant of components also taking place that will be arms and legs and vital organs like stomach and lungs start to find their direction. The different components of all the vectors that will help in making heart, which had formed separately, make their resultant to beat.

We know that a subset W of a vector space V over a field K, is said to be a subspace of V if W is itself a vector space over K with respect to the operation of vector addition and scalar multiplication. In other words, W is a subspace of V iff (i) W is non empty (0 vector belongs to W) (ii) W is closed under vector addition (iii) W is closed under scalar multiplication.

By this time the baby's navel (Zero vector of the subspace) has taken its proper place. During the time a curve (the umbilical cord) is forming, which is attached to the uterus at one end and the baby's navel, which can now be treated as zero vector, at other end. This curve is lifeline that provides the baby with nourishment by means of scalars. By the end of the second month the infinite system of vectors with an outline in the womb converted into a set of vectors has the tendency to move a step to be subspace of the original vector space i.e., mother's body. The vectors that will make the shape of eyes change their direction from brain to face with respect to zero vector.

With in six weeks concept of negative of vectors come into existence when the eyes which appeared in simple form in the first month develop lens and retina; the eyelids start to take shape. The ears continue to develop. By seven weeks the outer ear is present, and the inner ear, with its hearing and balancing mechanisms, is well established . The whole process takes place in opposite direction assuming that line

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of symmetry passes through the zero vector. No doubt distinct vectors (cells) to form different body parts follow the rules of commutativity and associativity.

Brain waves have been recorded by EEG (electro- encephalograph) in the human embryo 40 days after fertilization as the different cells of the brains get multiplied by the oxygen, a scalar from the field of chromosomes in substancal form, and added as vectors makes the brain to work to a little extent. We can say that the brain, resultant of different components of the brain, gets multiplied by the oxygen to show the brain waves existence. At this stage distributive law of a scalar over vectors is well defined.

A British study shows that the baby's movements begin at the same time as sensory nerves begin to grow into the spinal cord in the second month of pregnancy; the nerve fibres respond to touches to the skin and movement of the limbs. At this stage the baby's sensory nerves appear to be more sensitive than those of the adult or newborn baby.

After emplantation, the embryo develops a protective, fluid-filled capsule, can be treated as a unit scalar, which surrounds and cushions the developing body to prevent injury but doesn't help in body development. It helps in establishing the well settled mechanishm to make our body work. The Embryo and fluid are enclosed in two membranes, an inner amnion and an outer chorion. The chorion is covered in rootlike tufts, some of which form the early placenta - an organ made by the baby and the mother which transfers positive scalars(nutrients) from the mother's bloodstream and removes negative scalars(waste products) from the child's, though mother's and baby's circulatory systems remain separate. The placenta also produces hormones to maintain the pregnancy. In the ninth month it will alter the mother's hormonal balance and triggers off the birth process and a force field is responsible which causes labour to begin.

The baby is connected to the placenta by the umbilical cord, the lifeline channelling nourishment in and taking wastes out, which will be cut close to the baby's abdomen at birth and will leave the mark of the navel. During pregnancy the baby obtains oxygen from the mother's blood via cord and placenta, so does

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not drown in the surrounding fluid. While getting the nutrients from placenta and cord the baby follows distributive law of a vector over scalars. Also for m, n working as scalars and a cell, say **a,** treated as a vector satisfies the axiom (mn)**a** = m(n**a**). That is to say the mixture of two scalars has the same effect on a body cell as a scalar effects on a body cell which is obtained after getting multiplied with another scalar.

The embryo increases in size from 5mm at four weeks to 40 mm by the end of the eighth week. The baby in the womb is usually measured from the top of the head to the bottom of the spine (crown-rump lengths). By the sixth week from fertilisation tiny fingers appear, followed within days by the toes. By the seventh week the baby has individual fingerprints; no two sets of fingerprints are ever the same. Even in utero the baby has unique characteristics.

Around eight weeks the components for different vectors(baby's cartilage skeleton) begins to reduce into single vector(bone) for further development. The body is essentially complete. Now the baby can be referred to as the foetus - a Latin term meaning "young, offspring." Latin- or Greek-derived names are given to human beings at successive phases of development, e.g. "zygote" for the newly-conceived, "neonate" for newborn baby, "adolescent" for growing-up teenager, "geriatric" for a pensioner. These terms simply identify different stages in the human lifespan which begins at fertilisation.

Linear Combination of Vectors to Establish Mechanishm in Different Parts of a Baby's Body

With the beginning of the third month linear combination of vectors come into force to give proper shape to different parts of our body. Let V be a vector space over a field K and let $\mathbf{a_1}$, $\mathbf{a_2}$, $\mathbf{a_3}$, ……, $\mathbf{a_n}$ belongs to V. Any vector in V of the form $k_1\mathbf{a_1} + k_2\mathbf{a_2} + k_3\mathbf{a_3} + ……..+ k_n\mathbf{a_n}$ where the k_i belong to K, is called a linear combination of $\mathbf{a_1}$, $\mathbf{a_2}$, $\mathbf{a_3}$, ……, $\mathbf{a_n}$.

By the end of the twelfth week the area of region that is isomorphic to R^{46} where the vector formation is taking place to form a subspace measures almost 90mm and weighs 45g. The angle between any two cells of baby's face, at first increased, now decreases; distinct combinations of vectors(cells) marked for

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the eyes region are taking place to form the internal and external parts of eyes. The angle between eyes decreases protection from about 10 weeks until the sixth month. Boyhood or girlhood is now obvious by means of a linear combinations of vectors(cells) of sex organ.

Two British consultants, one caring for pregnant women and the other for children after birth, describe human development at this stage:

"Nine weeks after conception the baby is well enough formed to bend his fingers round an object in the palm of his hand. In response to a touch on the sole of his foot he will curl his toes or bend his hips and knees to move away from the touching object. At 12 weeks he can close his fingers and thumb and he will open his mouth in response to pressure applied at the base of his thumb."
From a simple, generalised response to stimulation at 6 weeks gestational age, the foetus develops an almost complete range of responses to touches on the skin by 12 weeks with the help of linear combinations of vectors marked for distinct parts of our body.

The brain and nerve fibres must be functioning for anyone to feel pain with the help of scalars set in linear combinations of vectors. Brain cells which are essential for consciousness in the adult are known to be present in the foetus by 10 weeks. Nerve fibres which transmit pain impulses are known to be present before fibres inhibiting pain are completed. According to a scholarly study of the available evidence, this implies that the first trimester foetus may be more susceptible to pain than slightly older subjects. The first trimester of pregnancy is the first three months.

In other words, if the baby can experience pain before the body's mechanisms to suppress pain have developed, this means that the baby may be able to feel pain at a much earlier stage than was previously thought, and perhaps even more keenly in the first three months of pregnancy than later.

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At 11 weeks after conception different vectors of the foetus starts to use the concept to get multiplied by identity scalar(swallow the surrounding amniotic fluid) and remain the same as ever before. He/She pass it back in his urine. From this process he/she learns the lesson to get multiplied by the scalars by his own mechanism for the first time. Swallowing (To get multiplied by the unit vector) prepares the baby for taking in milk at birth. Thumb-sucking has also been recorded in the foetus. Foetal breathing movements have been detected as early as 11 weeks. Although the baby does not breathe air inside the fluid-filled amnion, these movements help develop the mechanism of respiratory organs.

Working of Mechanishms Established in Different Parts of a Baby's Body

During the fourth month linear combination of vectors take place in a subset (System of hand and foot fingers) to form finger nails. In this month the various vectors of distinct subsets get connected by nerves system like wires are attached to the main for lighting and other function of lighting to get in work. As a result the gallbladder begins to make bile, and the baby makes its own blood with its own bone marrow. By the middle of this month linear combination of vectors (cells) of sex organ take a perfect form of male or female. A different type of vectors which are very small in magnitude and termed as hair begin to form including hair on the head, eyelashes, eyebrows and a fine dowry hair that covers the entire body called lanugo. This unique hair grows all over the body in swirly patterns and disappears shortly after birth. By sixteen weeks the region where the subspace is forming measures 140mm just over one third of the size the subspace will be at full term and weighs around 200g. The mechanism established in most important vector (heart) now pumps 30 litres of blood a day.

In this month the sum of different subsets of the subspace take place and the baby starts to react to the inside and outside world phenomenon. For example, There is evidence that from four months the foetus responds to sound. Doctors testing unborn children for deafness, while monitoring their reactions to noise with ultrasound (a technique for visualising the children in utero), have observed eye movements and "blink-startle" responses in foetuses of 16 to 32 weeks gestation. The baby hears sounds from the outside world as well as from the mothers heart and digestive system. "In fact the mechanism of vectors

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constituting the inner ear of the foetus is completely developed by mid-pregnancy, and the foetus responds to a wide variety of sounds. He is surrounded by a constant very loud noise in the uterus - the rhythmical sound of the uterine blood supply punctuated by the noises of air passing through the mother's intestine. Loud noises from outside the uterus such as the slamming of a door or loud music reach the foetus and he reacts to them." Tests using different types of music indicate that the baby even appears to have preferences: "A four- or five-month-old foetus definitely responds to sound and melody - and responds in very discriminating ways. Put Vivaldi on the record player and even the most agitated baby relaxes ... In a film made at the City of London Maternity Hospital, Yehudi Menuhin demonstrated that it was possible to contact the unborn via music." Babies learn to recognise their mothers' voices whilst in the womb and even to recognise stories which are read to them in the womb. Newborn babies whose mothers watched neighbours during pregnancy have been seen to stop crying and become alert when they hear the theme tune after birth.

From the sixteenth week the foetus responds to light. If a blinking light is shone on to the mother's abdomen, the foetal heartbeat fluctuates."In late pregnancy, some light penetrates through the uterine wall and amniotic fluid, and foetal activity has been shown to increase in response to bright light." The womb is a more stimulating environment than some people think; its occupant is alert and responsive.

After 20 weeks the region of subspace formation is 190mm and weighs 460g. The linear combination of vectors formed as muscles and limbs which are much stronger this month than the last give the baby the ability to use other vector quantity such as force to explore this little world, as well as push and kick at things. If the baby’s thumb gets close to its face it grabs it and begins sucking on it as he learned in third month from getting multiplied with the unit scalar. This instinct is for when, after birth, it is ready to breastfeed. Inside the intestine the first negative scalar (stool) called meconium forms. If the baby is a girl she begins to develop her own eggs which decades later will possibly begin this vector formation cycle again.

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A baby born during the 22nd week has a 14.8 percent chance of survival and half of these survivors are brain damaged, either lack by most important scalar (Oxygen) or too much oxygen from the ventilator. Neonatologists predict that no baby will ever be viable before 22nd week, because before than the lungs are not fully formed.

After 26 weeks the the region of supspace formation is 12 inch long and almost two pounds. The combination of vectors that have taken place within the subset "a pair of lungs" setup their own mechanism to breathe even the baby will not use them until the moment of birth. The different operation of a vector space are well established within the subset termed as brain by this time. A transformation for creating a vector field of rudimentary brain waves come into existence to turn on the higher functions of the fetal brain for the first time.

By the seventh month vector field of rudimentary brain waves is detectable which is similar to those in adults. The dirction of different subsets of the subspace is towards the zero vector by the typical fetal position with its legs bent into its chest. The subspace formation is complete by this month. As a result the baby is very active during this month. Indeed as the mother lies in bed at night, she might actually see her whole stomach change shape as her baby shifts its position.

As a result of formation of vector field of brain waves, the eyelids, which formed in the second month, begin to open, awakening the baby's sense of sight. Now it can hear. The brain also rapidly grows, becoming folded and wrinkled. Each section is assigned its duty, like controlling speech or recording memories.

Preparation by the Subspace for its Own Existence as a Unique Vector Space

By the eighth month the region of subspace formation is 18 inch and weighs about 5 pounds. At this stage the subspace is preparing to free from the original vector space. If a subspace makes its own existence at this time it has good chance to be a perfect vector space in itself. The subspace gets positive scalars from

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the original space to protect it from negative functions (plethora of diseases) that could infect it after separation. But the effect of these scalars goes away after separation. However the length of this effect can be extended by getting these scalars via the original space through breastfeeding.
In the ninth month the rate of change in vectors of the supspace get slow as the subspace is ready for separation.

Existence of a Linear Operator for Labour and Delivery

As every vector space V of dimension n over a field K is isomorphic to $\mathbf{R^n}$, therefore a vector space over the field of chromosomes is isomorphic to $\mathbf{R^{46}}$. In the last weeks of pregnancy a linear operator T from $\mathbf{R^{46}}$ to $\mathbf{R^{46}}$ exists which rotate the position of each vector of the subspace about the zero vector by an angle of 45 degree in approximation, as a result the baby lies head downwards, as the head is normally the first part to emerge at birth. Occasionally, if a baby's position of personal comfort is not changed to fit in with the normal birth process, there may be a "breech" presentation - rear end first - which needs medical attention.
After this eventually a force field is created and the mother's labour begins as (following hormonal signals including that from the placenta) the muscular uterus contracts to expel the baby. The cervix (neck of the womb) gradually opens to allow the baby to pass into the vagina (birth canal). The unit scalar amnion fluid releases. Contractions become more frequent as the baby is pushed through the cervix and vagina. If the mother has attended ante-natal classes she will have learned what to expect and how to control her breathing and pushing process. A midwife and/or a doctor supervises the mother and baby during labour. The baby's father may wish to be present to lend support and encouragement and to see his baby from the moment of birth.

After labour, which varies in length but usually lasts some hours, the baby is born. A gasp and a cry start the mechanism of vectors in lungs working. The umbilical cord is cut from the zero vector and the baby is examined and weighed. Normal birthweight is approximately 3,400 grammes or about 7½ lb. Finally the

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membranes and placenta are expelled. The baby no longer needs a direct life support system as he or she can now breathe air and take milk.

A Unique Vector Space that is Isomorphic to R^{46}

After delivery babies who have been studied in utero show the same individual behaviour that was observed while they were in the womb: "After birth you see many babies sleeping in the odd positions that they chose to rest in within the uterus prior to birth ... The good drinkers in utero are the good drinkers in the nursery and the dainty, tedious swallowers in utero are the tedious ones out of the uterus as well ... The behaviour traits also bridge the birth." From the one-celled zygote to the multi-million-celled infant and adult, every human being is a distinct individual and now can be treated to work as a vector space that is isomorphic to $\mathbf{R^{46}}$.

Conclusion

Mathematics is really a more restrictive limited form of language. The power of language lies in the way meaning can be conveyed through form and transformation. But is it really true that mathematics is nothing more than a limited and abstract version of natural language? I would argue that mathematics is both more, and less, than a language. Since it involves highly codified forms, mathematics makes it easy to carry out calculations, to demonstrate proofs and to arrive at true assertions. But, in my opinion, this is only a surface difference, a feature of the convenience and economy of mathematics over ordinary language. A more significant way in which mathematics goes beyond language is that it involves a particular kind of visual and sensory motor thinking that does not seem to be characteristic of ordinary language. On the other hand, mathematics is also less than a language, in that it lacks the richness, the ability to deal with nuance, the inherent ambiguity and the rich strategies for dealing with this ambiguity. In this sense, mathematics is a limited, technical language in which much that is of deep human value cannot be expressed. It demands for a special kind of thinking for conversation.

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