Society for the Protection of Unborn Children

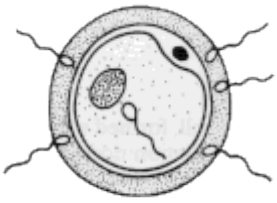
Human development: conception to birth

The first month

Fertilisation

Every human being begins life as a single cell, formed when father's sperm fertilises mother's egg. Fertilisation normally takes place in the mother's Fallopian tube, 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) which passes slowly along the tube towards the womb cavity



Day 1: Fertilisation.
0.14mm

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 many sperm cells released by her partner may travel up to the Fallopian tube and one may fertilise the egg. When fertilisation is completed and the nuclei of egg and sperm have combined, a new being comes into existence and 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.

A consultant specialising in the care of pregnant women writes: "Life does not begin with birth. When born, we are already nine months old... we have a responsibility to learn how to study the life *in utero*, and how to care for it"[1]

Heredity

The cells of living beings contain DNA (deoxyribonucleic acid), the substance in the nucleus that enable cells to reproduce and transmit characteristics from generation to generation. When cells divide, the DNA takes the form of chromosomes - the units carrying the genes that 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. Human body cells normally contain 46 distinctively human chromosomes. But an egg and a sperm cell contain only 23 chromosomes each, to allow for their adding together at fertilisation: sperm and ovum are termed gametes (from a Greek word for "marriage partners"). When they "marry" they make one completely new cell - the human embryo, zygote or conceptus - with 46 chromosomes carrying a fresh, unique combination of genes. At fertilisation this human embryo is about 0.1mm in diameter. 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.

Gender

A baby's sex is determined at fertilisation. A chromosome from the father's sperm determines whether the child is male or female. If an X chromosome is present the baby is a girl; if a Y chromosome is carried by the sperm instead, the baby is a boy.

Twins

Occasionally two eggs are released by the ovary and fertilised. This results in fraternal twins who are different in appearance and may be of different sexes because their genes form from two eggs and two sperm cells.

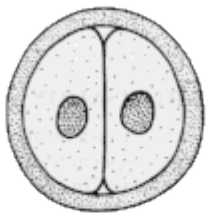
Rarely, one embryo splits into two and both cells develop separately, as identical twins, similar in appearance.

"They have the same genetic make-up and apparently the whole genetic message is the same in both of them. Nevertheless, they are obviously different human beings."[2]

Blueprint, builder and house

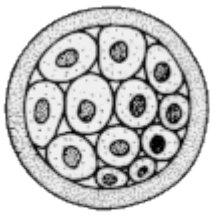
The embryo is not simply a set of instructions for making a new human being, like a blueprint for building a house. A blueprint is inert and cannot carry out instructions, but the embryo is active and begins work at once. A house needs builders, carpenters, electricians and plumbers to complete it; but the embryo has the ability to grow spontaneously, moving on to other phases of development and constructing the skeleton, flesh, nerve connections and a waste disposal system of the human body. After a house is built, a blueprint remains separate; but the embryo - already an essential human by virtue of the genes - is blueprint, builder and "house" together.

Implantation



Day 2: Zygote divides
0.14mm

After fertilisation the single cell splits into two, then the two cells double to four, four to eight, eight to sixteen and so on. Because the cell cluster looks superficially like a berry it is called the morula (Latin for "mulberry"), but the new life is always biologically human (species Homo sapiens).



Day 3: Morula. 0.14mm The journey along the Fallopian tube continues slowly for about four days. Growth increases. By the time the womb cavity is reached, the cell cluster becomes hollow and fluid-filled, and is referred to as the blastocyst. However, this is not an inert clump of cells but a busily developing human individual: differentiation (organisation into different parts and functions) is already taking place. Meanwhile the uterus is forming a spongy lining within which the embryo will implant. To achieve this the embryo burrows into the wall of the womb and is covered over by the lining of the womb. This begins 6 days after fertilisation and is completed within the next 7 days.

If fertilisation has not taken place, the lining of the uterus 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 usually her first indication of pregnancy.

Estimating length of pregnancy

Generally a woman does not know the exact date of her baby's conception. When she misses a period she may take a pregnancy test; she should see a doctor promptly to obtain professional care for herself and her child. The doctor takes the date of the first day of the mother's last menstrual period as the starting-point for a 40-week pregnancy. This gives the baby's gestational age. However since fertilisation only occurs when the ovum is released from the ovary, some two weeks from the beginning of the last period, the baby's actual (conceptional) age is also two weeks less. Full-time delivery occurs 38 weeks after fertilisation, but 40 weeks after the mother's last menstrual period. (In this booklet all developments of the embryo and foetus are dated from the time of conception, or fertilisation unless stated otherwise.)

Protection and life support

During and after implantation the embryo develops a protective, fluid-filled capsule which surrounds and cushions the developing body to prevent injury. 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 nutrients from the mother's bloodstream and removes 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 - although we are still unsure what 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 not drown in the surrounding fluid.

Body development

Day 22:
Heart starts to beat. 2mm

By 25 days from fertilisation the body is developing. Head and trunk appear and tiny arm buds begin to form, followed by leg buds. The early embryo seems to have a "tail", but this is really a protective covering for the spinal cord. Because the central nervous system (brain. spine and spinal cord) is so important, governing sensory and motor functions, the embryo's body is designed for rapid growth of head and back.

By 21 to 25 days the baby's heart is beating. Other internal organs are present in simple form and functioning as they grow. Early facial features appear. The doctor who performed the first-ever blood transfusion to an unborn baby has described the embryo at the end of the first month from fertilisation:

Day 29:
Crown to rump, 5.0mm

"By 30 days, just two weeks past mother's first missed period, the baby - one quarter of an inch long - has a brain of unmistakable human proportions, eyes, ears, mouth, kidneys, liver, an umbilical cord and a heart pumping blood he has made himself."[3]

The second month

Growing

The embryo increases in size from 5mm at four weeks to 4Omm 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).

Hands and feet

Day 42:
Crown - rump 23.0-23.5mm

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.

Eyes and ears

By six weeks 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 (see page 15 'Hearing')

Movements

Spontaneous movements begin at seven weeks:

"By 45 days, about the time of the mother's second missed period, the baby's skeleton is complete in cartilage, not bone, at first; ... he makes the first movements of his body and new-grown limbs, although it will be another 12 weeks before his movements are strong enough to be transmitted through the insensitive uterus to be detected by the mother's sensitive abdominal wall."[4]

Brain function

Brain waves have been recorded by EEG (electro- encephalograph) in the human embryo 40 days after fertilisation.[5]

Response to touch

Day 35:
Crown to rump 12.0-14.0mm

Human embryos of five weeks gestational age have been seen to move away from an object touching the mouth area. The sensitive area extends to include the rest of the face in the sixth and seventh weeks and the palms of the hands and soles of the feet in the eighth and ninth weeks respectively.[6]

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."[7]

From embryo to foetus

Around eight weeks the baby's cartilage skeleton begins to turn into bone. 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.

The third month

Development

By the end of the twelfth week the baby measures almost 90mm and weighs 45g. The baby's face, at first broad, now becomes narrower; the eyes are closed for protection from about 10 weeks until the sixth month. Boyhood or girlhood is now obvious.

Sensitivity

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."[8]

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.[9]

Feeling pain

The brain and nerve fibres must be functioning for anyone to feel pain

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."[10]. 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.

The same study concludes that there is a likelihood that the

"foetus has started to acquire a sentient capacity perhaps as early as six weeks, certainly by nine to ten weeks of gestation. Anatomical examination of such foetuses indicates the probability that differentiation sufficient for reception, transmission and perception of primitive pain sensation has already occurred."[11]

Practising for life outside the womb

"At 11 weeks after conception the foetus starts to swallow the surrounding amniotic fluid and to pass it back in his urine. He can also produce complex facial expressions and even smile."[12] Swallowing prepares the baby for taking in milk at birth. Thumb-sucking has also been recorded in the foetus.[13]

Foetal breathing movements have been detected as early as 11 weeks [14]. Although the baby does not breathe air inside the fluid-filled amnion, these movements help develop the respiratory organs.

Four to five months

Enlargement of baby and uterus

By sixteen weeks the baby measures 140mm from crown to rump, just over one third of the size he or she will be at full term, and weighs around 200g. The heart now pumps 30 litres of blood a day. The uterus expands and changes shape to accommodate the growing baby; pregnancy begins to show externally. The doctor can tell approximately how advanced the pregnancy is by locating the fundus (the top part of the uterus between the Fallopian tubes, which stretches upwards towards the mother's chest as the uterus expands).

Hearing

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.[15]

The authors of a textbook on the unborn which is used in medical schools world-wide explain why the foetus can hear while immersed in fluid:

"The ears of the foetus function as early as the fourth month, and there is evidence that it hears a good deal. One might object that if a person dives under water and someone else talks to him he hears only a muffled sound. This is true. The sound is muffled by the cushion of air remaining in the auditory canal outside the ear drum. But the foetus living in the amniotic fluid has no muffling air cushions around its ear drum - and water conducts sound better than air does. The silent world of the foetus (or, below the surface of the ocean) is a fantasy, unfounded in reality."[16]

The baby hears sounds from the outside world as well as from the mothers heart and digestive system: "In fact 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."[17] 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."[18] Babies learn to recognise their mothers' voices whilst in the womb [19] and even to recognise stories which are read to them in the womb.[20] 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.[21]

Sensitivity to light

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.[22] "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."[23] The womb is a more stimulating environment than some people think; its occupant is alert and responsive.

The fifth month and beyond

After 20 weeks the baby is 190mm from crown to rump and weighs 460g. Head hair, eyebrows. eyelashes and nails are growing. To protect the baby's skin from prolonged contact with the amniotic fluid, a greasy substance called vernix covers the body. Between this stage and birth the baby will gain weight and will develop an insulating layer of fat beneath the skin. He or she will also receive maternal antibodies against some infections as a temporary protection until the infant's own immune system is better developed.

Waking and sleeping

Foetal activity is affected when the mother is tired or under stress.[24] The baby is usually most notably active when the mother is lying down at night. The mother feels the baby's kicking and may notice sharp movements when the baby gets hiccups after drinking the amniotic fluid or practises its breathing movements. In later pregnancy the foetus has been observed to show "behavioural states" - waking, calm sleeping, and "rapid eye movement sleep" which is associated with dreaming in adults.[25]

The quest for comfort

The baby still has some room to manoeuvre inside the womb and seeks the position which feels most comfortable:

"It is very easy to demonstrate now with ultrasound that the babies make the most of all the space and room available to them ... We know that foetal comfort determines foetal position, that changes in maternal position provoke baby to seek a new position of comfort."[26]

Survival outside the womb

If the baby is born too early, there is still a good chance that he or she will survive, given special medical care. A document from the Royal College of Obstetricians and Gynaecologists (the professional body of doctors who treat pregnant women) states: "In 1984, 72 per cent of liveborn infants of 22 to 27 weeks' gestation born at the Bristol

Maternity Hospital survived, as did 64 per cent of infants of 500 to 999 grammes birthweight."[27]

These percentages had increased from previous years. With advances in technology and in understanding of human foetal development, premature babies' chances of survival are improving.

These figures refer to the length of the pregnancy from the time of the mother's last menstrual period. and not to the age of the baby from fertilisation. which would usually be two weeks less. (see 'Estimating length of pregnancy', section 1, above)

Birth

Labour and delivery

In the last weeks of pregnancy 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.

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 amnion tears and releases its fluid (this is often referred to as "the waters breaking"). 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 lungs working. The umbilical cord is cut and the baby is examined and weighed. Normal birthweight is approximately 3,400 grammes or about 7½ lb, but considerable variations sometimes occur because of genetic factors, health problems and outside influences such as the mother's smoking during pregnancy.

Finally the 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.

The same before and after birth

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."[28] From the one-celled zygote to the multi-million-celled infant and adult, every human being is a distinct individual.

Mother and baby

Ante-natal care

A doctor caring for a pregnant woman has two patients, the mother and the baby. As soon as he is aware of the pregnancy, the doctor will take the needs of both into account.

The doctor should know about a pregnancy as early as possible so that any medicines he prescribes are safe for both his patients. This is particularly important as the pregnancy may, of itself, cause symptoms such as headaches and fatigue for which the mother may seek medical treatment. If the mother has "morning sickness", caused by normal hormonal responses to pregnancy, a harmless antacid can be given. Tablets of iron and folic acid (a B vitamin) are routinely prescribed to prevent anaemia: it is safe and important to take these.

Pregnancy can also lead to an increased sense of well-being and contentment. Many women find that their complexions improve and they feel more relaxed as a result of the hormonal changes in their bodies.

During pregnancy the mother should attend her doctor's ante-natal clinic for regular checks on her weight and blood pressure, and on her baby's heartbeat, growth and position in the uterus. Arrangements will be made for the baby's birth at home or (more likely) in hospital. Mother and perhaps father may also attend parentcraft classes: there they will learn how the baby develops, how to care for mother and child before and after birth, and how to cope with the process of birth itself.

The mother does not need to "eat for two" in the sense of increasing her food intake. Adequate amounts of protein, vegetables, fruit and milk should be taken (particularly milk, since the mother needs to replace the calcium taken from her system to make the baby's bones). The doctor will advise on any special dietary needs. During pregnancy a mother can expect to gain around 12kg (allowing for baby. placenta, fluid and her own physical changes), but weight gain should not be excessive and too much carbohydrate should be avoided.

Foetal breathing movements are substantially decreased if the mother smokes cigarettes during pregnancy. There is evidence that prematurity, stillbirth and slower development may be related to this practice.[29] It is important not to smoke during pregnancy or when near a pregnant woman.

Even moderate amounts of alcohol taken in early pregnancy may affect the child's growth and development (including that of the brain); heavy drinking carries a still higher risk.[30] During the first three months of pregnancy the developing baby may be harmed by certain infections and drugs. For example, rubella (German measles) may damage the baby's heart, eyes or ears if the mother contracts it in early pregnancy. Such harm can be prevented by receiving immunisation against rubella as a small child or as a schoolgirl, long before pregnancy occurs. However, by the end of the third month the baby is less likely to develop a disability because the body is well developed.

Post-natal care

Mother and baby will be visited by the midwife for some days after the birth to check that all is well with both of them. The mother should return to her doctor six weeks later for her post-natal examination to be sure that the uterus has regained its former shape and that she is otherwise in good health.

Glossary

amnion	the fluid-filled membrane enclosing the baby in the womb.
ante-natal	before birth.
blastocyst (Greek, "sprout pouch')	the hollow, fluid-filled ball of cells which is the developing embryo at one week after fertilisation.
cervix	neck of the womb.
chorion	the outer capsule containing amnion, fluid and baby within the womb.
chromosome	part of a cell nucleus, made of DNA, carrying the genes; each species of animal and plant has a characteristic number of chromosomes per cell, except in reproductive cells which have only half that number to allow for their combination at fertilisation.
differentiation	development of cells to perform specialised functions (making nerves, bones, organs etc.).
DNA (deoxyribonucleic acid)	threadlike molecule in the nucleus of a living cell which can reproduce itself and transmit hereditary characteristics.
EEG (electroencephalograph)	an instrument which detects and records brain activity.
embryo (Greek, "to teem within")	stage of human development during the first eight weeks after fertilisation.
fallopian tubes	two tubes, one on each side of the womb, connecting it with the ovaries; fertilisation normally takes place in one of the Fallopian tubes.
fertilisation	the joining of sperm with ovum, completed when their nuclei are combined, to make a genetically new individual.
foetus (Latin, 'young, offspring')	the developing human from eight weeks after fertilisation up to birth.
fraternal twins	twins who do not look alike because they develop from two different eggs and sperm cells.
full-time delivery	birth of a baby after a completed nine-month pregnancy (i.e. not a premature birth).
fundus	the top part of the womb, lying between the Fallopian tubes, which expands upwards as pregnancy advances and enables the doctor to assess the length of pregnancy.
gamete (Greek, "marriage partner")	reproductive cell; egg or sperm.

gene	factor controlling specific inheritance, characteristic eg.eyecolour
gestational age	the baby's age calculated by estimating pregnancy as starting from the first day of the mother's last menstrual period.
hormone	substance produced by an organ or a gland which influences other organs or the whole body.
homo sapiens (Latin, "thinking man")	the human species.
identical twins	twins who look alike because they result from one egg and sperm when the zygote splits into two separately developing cells.
labour	the process of expelling baby, membranes and placenta from the womb.
morula (Latin, "mulberry")	the earliest stage of human embryo development; the first four days of life when the growing cell cluster looks like (but is not) a berry.
ovary	the egg-producing organ; normally a woman has two ovaries which take turns to release one egg per month.
ovum	egg (plural ova).
placenta	a temporary organ within the uterus which transfers nourishment and oxygen from the mother, removes waste products from the baby, and makes hormones to maintain and end pregnancy. Expelled after the baby is born, it is then also known as the "afterbirth".
post-natal	after birth.
prematurity	the baby is born before 37 completed weeks since the mothers last period and needs special care.
sentient capacity	the ability to feel sensations such as pain.
stillbirth	the baby is born dead.
trimester	a three month period of pregnancy. The first trimester covers the first to the third months; the second trimester the fourth to the sixth months; and the third trimester the seventh to the ninth months.
ultrasound	a technique for viewing the unborn child: high-frequency sound waves directed through the mothers abdomen send back signals which are converted to images on a screen.
umbilical cord	a temporary lifeline connecting the unborn child with the placenta, channelling nourishment from the mother and removing wastes from the baby.
uterus	the womb; *in utero* (Latin) in the womb.
vagina	the birth canal.
vernix	a greasy coating protecting the unborn baby's skin from prolonged contact with the fluid in the amnion.
zygote (Greek, 'joining')	the new, one-celled being formed when sperm fertilises egg; the zygote of the species Homo sapiens is a human being at the earliest stage of life.

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- Dr John McLean, Senior Lecturer in Embryology and Anatomy, University of Manchester
- Professor David Morrell, Professor of General Practice, Guy's Hospital & St Thomas' Hospital
- Professor David Short, Emeritus Professor of Clinical Medicine, University of Aberdeen
- Professor Ronald Taylor, Department of Obstetrics and Gynaecology St Thomas' Hospital
- Dr Margaret White, General Practitioner