What are the two big groups into which cells are classified?
Cells can be classified as eukaryotic or prokaryotic.Prokaryotic cell is that without a delimited nucleus. Eukaryotic cells are those with nucleus delimited by membrane.

Do bacteria cells have a nucleus?
In bacteria the genetic material is dispersed in the cytosol and there is no internal membrane that delimits a nucleus.

What are the chemical substances that compose the plasma membrane?
The main constituents of the plasma membrane are phospholipids, proteins and carbohydrates. The phospholipds, amphipathic molecules, are regularly organized in the membrane according to their polarity: two layers of phospholipids form the lipid bilayer with the polar part of the phospholipids pointing to the exterior of the layer and the non-polar phospholipid chains in the interior. Proteins can be found embedded in the lipid bilayer and there are also some carbohydrates bound to proteins and to phospholipids in the outer face of the membrane.

What is the difference between plasma membrane and cell wall?
Plasma membrane and cell wall are not the same thing. Plasma membrane, also called cell membrane, is the outer membrane common to all living cells and it is made of a phospholipid bilayer, embedded proteins and some appended carbohydrates. Because cell membranes are fragile, in some types of cells there are even outer structures that support and protect the membrane, like the cellulose wall of plant cells and the chitin wall of some fungi cells. Most bacteria also present an outer cell wall made of peptidoglycans and other organic substances.

Concerning the presence of the nucleus what is the difference between animal and bacterial cells?
Animal cells (cells of living beings of the kingdom Animalia) have an interior membrane that delimits a cell nucleus and thus they are eukaryotic cells; in these cells the genetic material is located within the nucleus. Bacterial cells do not have organized cellular nuclei and so they are prokaryotic cells and their genetic material is found dispersed in the cytosol.

What are the main structures within the cell nucleus?
Within the cell nucleus the main structures are: the nucleolus, an optically dense region, spherical shaped, where there are concentrated ribosomal RNA (rRNA) associated to proteins (there may be more than one nucleolus in a nucleus); the chromatin, made of DNA molecules dispersed in the nuclear matrix during the cell interphase; nuclear envelope, the double membrane that delimits the nucleus.

What are the substances that constitute the chromatin?
The chromatin, dispersed in the nucleus, is a set of filamentous DNA molecules associated to nuclear proteins called histones and scaffolding proteins.

Of what substances is the nucleolus made? Is there a membrane around the nucleolus?
Nucleolus is a region within the nucleus made of ribosomal RNA (rRNA) and proteins. It is not delimited by membrane.

What are the main cytoplasmic structures present in animal cells?
The main cytoplasmic structures of the cell are the centrioles, the cytoskeleton, lysosomes, mitochondria, peroxisomes, the Golgi apparatus, the endoplasmic reticula and ribosomes.

Where in the cell can ribosomes be found? What is the main biological function of ribosomes?
Ribosomes can be found free in the cytoplasm, adhered to the outer side of the nuclear membrane or associated to the endoplasmic reticulum membrane defining the rough endoplasmic reticulum. Ribosomes are the structures where protein synthesis takes place.

What is the difference between smooth and rough endoplasmic reticulum?
The endoplasmic reticulum is a delicate membranous structure contiguous to the nuclear membrane and present in the cytoplasm. It forms an extensive net of channels throughout the cell and is classified into rough or smooth types. The rough endoplasmic reticulum has a great number of ribosomes attached to the external side of its membrane. The smooth endoplasmic reticulum does not have ribosomes attached to its membrane. The main functions of the rough endoplasmic reticulum are synthesis and storage of proteins made in the ribosomes. The smooth endoplasmic reticulum plays a role in the lipid synthesis and, in muscle cells, it is important in the conduction of the contraction stimulus.

A netlike membranous complex of superposed flat saccules with vesicles detaching from the extremities seen in electronic microscopy. What is the observed structure? What is its biological function?
What is being observed is the Golgi complex, or Golgi apparatus. This cytoplasmic organelle is associated with chemical processing and modification of proteins made by the cell and with storage and branding of these proteins for posterior use or secretion. Vesicles seen under the electronic microscope contain material already processed, ready to be exported (secreted) by the cell. The vesicles detach from the Golgi apparatus, travel across the cytoplasm and fuse with the plasma membrane then secreting their substances to the exterior.

On which organelle of the cell structure does intracellular digestion depend? What is the chemical content of those organelles?
Intracellular digestion occurs by the action of lysosomes. Lysosomes have digestive enzymes (hydrolases) that are made in the rough endoplasmic reticulum and stored in the Golgi apparatus. Lysosomes are hydrolase-containing vesicles that detach from the Golgi apparatus.

Which are the cell organelles that participate in cell division and in the formation of cillia and flagella of some eukaryotic cells?
The organelles that participate in the cell division and in the formation of cilia and flagella of some eukaryotic cells are the centrioles. Some cells have cillia (the bronchial ciliated epithelium, etc.) or flagella (flagellate protists, sperm cells, etc.); these cell structures are composed of microtubules originated from the centrioles. Centrioles also make the aster microtubules that are very important for cell division.

What are mitochondria? What is the basic morphology of these organelles and in which cells can they be found?
Mitochondria are the organelles in which the most important part of the cellular respiration occurs: the ATP production. Mitochondria are organelles delimited by two phospholipid membranes. The inner membrane invaginates to the interior of the organelle forming cristae that delimitate the internal space known as mitochondrial matrix and where mitochondrial DNA (mtDNA), mitochondrial RNA (mt RNA), mitochondrial ribosomes and respiratory enzymes can be found. Mitochondria are numerous in eukaryotic cells and they are even more abundant in those cells that use more energy, like muscle cells. Because they have their own DNA, RNA and ribosomes, mitochondria can self-replicate.

Why can mitochondria be considered the power plants of the aerobic cells?
Mitochondria are the “power plants” of aerobic cells because within them the final stages of the cellular respiration process occurs. Cellular respiration is the process of using organic molecule (mainly glucose) and oxygen to produce carbon dioxide and energy. The energy is stored in the form of ATP (adenosine triphosphate) molecules and later used in other cellular metabolic reactions. In mitochondria the two last steps of the cellular respiration take place: the Krebs cycle and the respiratory chain.

What is the endosymbiotic hypothesis about the origin of mitochondria? What are the molecular facts that support the hypothesis? To which other cellular organelles can the hypothesis also be applied?

It is presumed that mitochondria were primitive aerobic prokaryotes that were engulfed in mutualism by primitive anaerobic eukaryotes, receiving protection from these beings and offering energy to them. This hypothesis is called the endosymbiotic hypothesis on the origin of mitochondria.

The hypothesis is strengthened by some molecular evidence such as the fact that mitochondria have their own independent DNA and protein synthesis machinery, with their own RNA and ribosomes, and that they can self-replicate.

The endosymbiotic theory can be applied to chloroplasts too. It is supposed that these organelles were primitive photosynthetic prokaryotes because they have their own DNA, RNA and ribosomes and they can self-replicate too.

What are the main components of the cytoskeleton?

The cytoskeleton is a network of very small tubules and filaments distributed throughout the cytoplasm of eukaryotic cells. It is made of microtubules, microfilaments and intermediate filaments. Microtubules are formed by molecules of a protein called tubulin. Microfilaments are made of actin, the same protein that participates in the contraction of muscle cells. Intermediate filaments are made of protein too.

What are the functions of the cytoskeleton?

As the name indicates, the cytoskeleton is responsible for the support of the normal shape of the cell; it also acts as a facilitator for substance transport across the cell and for the movement of cellular organelles. In cells of the phagocytic defense system, like macrophages, cytoskeleton is responsible for the plasma membrane projections that engulf the external material to be interiorized and attacked by the cell.

Of which substance are microtubules made? In which structures and cellular processes do microtubules participate?

Microtubules are made of consecutive dimers of the protein tubulin (each dimer has an alpha and a beta tubulin associated). Microtubules participate in cell division, they are constituents of cilia and flagella and they also form the centrioles.

Of which substance are microfilaments made? What are the properties of these elements that give motility to cells?

Microfilaments are made of actin (a protein). The contractile association of actin with myosin and other cytoplasmic proteins give to microfilaments the ability to promote cell movement.

What are cell movements? How are these movements created?

Cell movements are movements performed by cell structures, like the movements of cilia and flagella, the pseudopod movements (in amoeba, macrophages, etc.), the cyclosis of the cytoplasm and the sarcomere contraction in muscle cells. Cell movements can be created by the cytoskeleton action, by differences of viscosity among cytoplasmic regions and by intracellular contraction systems.

What are cilia and flagella? How do these structures acquire movement? What are some examples of ciliated and flagellated cells in humans?

Cilia and flagella are structures found in some prokaryotes as well in some eukaryotic cells. They play defense, nutrition and movement roles for the cell. In eukaryotic cells of protists and animals they originate from centrioles that migrate towards the plasma membrane and differentiate into structures projected outside the cell. Each cilium or flagellum is made of nine peripheral pairs of microtubules and one central pair all covered by membrane. (In bacteria, flagella are made of a protein named flagellin and there can also be fimbria made of pilin.) In the fixation base of each cilium or flagellum in the plasma membrane there are proteins that work as molecular motors providing movement for these structures with energy spending. Due to this energy spending ciliated or flagellated eukaryotic cells have a large number of mitochondria. In humans ciliated cells can be found, for example, in the

bronchial and tracheal epithelium. In these tissues the cilia have the defensive function of sweeping mucous and foreign substances that enter the airways. Sperm cells are a typical example of flagellated cells, their flagellum is the propulsion equipment for the movement towards the ovule.

How does the amoeboid movement occur? What are examples of beings and cells that use such movements for locomotion?
Amoeboid movements are created by cytoplasmic movements and plasma membrane projections called pseudopods. Pseudopods appear from the contractile action of microfilaments. Amoeboid movements occur, for example, in amoebas (a protozoan), organisms that use their movement to find food. The leukocytes, cells of the immune system, when attracted by chemical substances (immune mediators) use amoeboid movements to get out from capillaries in regions of tissue damage to participate in the inflammatory process.

What are cells with a delimited nucleus called ? What are the main elements of the nucleus?
Cells with delimited nucleus are called eukaryotic cells. Organisms composed of one or more eukaryotic cells are called eukaryotes.
The mains elements of the nucleus are the chromatin (made of DNA molecules, histons and non-histo proteins), the nucleolus, and the nuclear envelope.

Do all eukaryotic cells have nucleus and only one nucleus?
There are eukaryotic cells without a nucleus and others with more than one nucleus. Osteoclasts, the cells responsible for resorption of the osseous matrix, for example, are multinucleate cells; striated muscle fibers are multinucleate too. Red blood cells are an example of enucleated specialized cells.

What are heterochromatin and euchromatin?
Chromatin is uncondensed nuclear DNA, the typical DNA morphology in interphase. In this phase of the cell cycle chromatin can be found as heterochromatin, more condensed and dark (in electronic microscopy) portions of DNA molecules, and as euchromatin, less condensed and lighter portions of DNA molecules. Since it is uncondensed the euchromatin is the biologically active portion of the DNA, i. e., the region that has active genes to be transcripted into RNA. The heterochromatin represents the inactive, repetetive portions of the DNA molecule.

In the phase when the cell is not dividing (interphase) is there activity within the cell nucleus?
In the interphase there is intense metabolic activity in the cell nucleus: DNA is duplicating, euchromatin is being transcripted and RNA is produced.

How is the chromosome region where the centromere is located called? How are chromosomes classified in relation to the position of their centromere?
The chromosome region where the centromere is located is called primary constriction. In microscopic view this region is narrower (a stricture) than most part of the chromosome.
According to the position of the primary constriction the human chromosomes are classified as acrocentric, submetacentric or metacentric.

What are the primary and the secondary constrictions of a chromosome? What is NOR?
Primary constriction is the narrower region of a condensed chromosome where the centromere is located. Secondary constriction is a region narrower than the normal thickness of the chromosome too. One type of the secondary constriction (satellite stalk) is related to genes that coordinate the formation of the nucleolus and control the ribosomic RNA (rRNA) synthesis. For this reason the contrictions - satellite stalks are called nucleolus organizer region (NOR). In humans, the NOR genes are clustered on the short arms of chromosomes 13, 14, 15, 21 and 22 (the *acrocentric* chromosomes).

What are homologous chromosomes? Which are the human cells that do not have homologous chromosomes?
In the nucleus of somatic cells of diploid beings every chromosome has its correspondent homologous chromosome, both containing alleles of the same genes related to same functions. This occurs because one chromosome of one pair comes from the father and the other comes from the mother of the individual. The chromosomes that form a pair with alleles of the same genes are called homologous chromosomes. In humans, there are 22 pairs of homologous chromosomes, autosomes, plus the pair of sex chromosomes, gonosomes (the sex chromosomes are partially homologous). The only human cells that do not have homologous chromosomes are the gametes since during meiosis the homologous chromosomes are separated.

How many chromosomes does a human normal haploid cell have? How many chromosomes does a human normal diploid cell have? How many are the sex chromosomes within each of them?
The human haploid cell is the gamete (egg cell and sperm cell). The human gamete has 22 autosomes and 1 gonosome, i.e., 23 chromosomes. The diploid cell is the somatic cell and it has 44 autosomes and 2 gonosomes, i.e., 46 chromosomes. Gametes have one sex chromosome and somatic cells have two sex chromosomes.

Of which structures is the nuclear envelope composed?
Eukaryotic cells have nucleus delimited by two membranes that continue with the membrane of the endoplasmic reticulum. The nuclear envelope, presents pores through which substances pass. There are also ribosomes adhered to its external surface.

Is cell division happening during the entire cell cycle? What is interphase?
Cell division properly occurs during the mitotic phase of the cell cycle. During interphase processes that are a preparation to cell division take place, like the duplication of DNA and centrioles. Interphase is the preceding phase and the mitotic is the following phase.

What are the three periods into which interphase is divided?
Interphase is the preceding phase to the mitotic division. It is divided into three periods, G1, S and G2 (the letter G comes from "gaps", meaning interval or breach, and the letter S comes from "synthesis", indicating the period in which DNA replicates).
In fact, "gap" is not totally appropriate for the periods immediately before and after the DNA synthesis. The idea of "growth" would be more adequate since in those periods (G1 and G2) the cell is growing to divide later in mitosis.

What are the events that mark the beginning and the end of the first interphase period? What happens within the cell in this period?
The first interphase period is the G1. It begins with the end of the preceding cell division, i.e., with the formation of the new cell and it ends with the beginning of DNA replication. In the G1 period the cell is growing.

What are the events that mark the beginning and the end of the second interphase period? What happens in the cell in this period?
The second interphase period is the S. It starts with the beginning of DNA replication and finishes with the end of that process. The main event in this period is the synthesis of new polynucleotide chains, each bound to each DNA chain that served as a template, i.e., the duplication of the original set of DNA molecules.

What are the events that mark the beginning and the end of the third interphase period? What happens in the cell in this period?
The third interphase period is the G2. It begins with the end of DNA replication and ends with the beginning of the first period of the mitotic phase. On G2 the cell is growing too and the duplication of centrioles occurs (only in cells that have these structures).

What is mitosis? What is the importance of mitosis?
Mitosis is the process in which one eukaryotic cell divides into two cells identical to the parent cell (generally identical, since alterations in genetic material can occur, more or less organelles may be distributed between the daughter cells, etc.) Mitosis is fundamental for asexual reproduction of eukaryotes, for the embryonic development, for the growth of multicellular beings and for tissue renewal.

Into which periods is mitosis divided?
Mitosis is divided into four periods: prophase, metaphase, anaphase and telophase.

What is the importance of mitosis for the embryonic development?
Every embryo grows from a single cell that undergoes rmitosis and generates other cells that also divide themselves by mitosis forming tissues and complete organs. The perfect regulation and control of each of those cell divisions are fundamental for the creation of a normal individual. Without mitosis the embryonic development would be impossible.

What are some examples of organs and tissues where mitosis is more frequent, less frequent or practically absent?
Generally in vertebrates mitosis is more frequent in tissues that require intense renewing due to their functions, like epithelial tissues and the bone marrow. Mitosis take place with low frequency in tissues of slow renovation, like the bones in adults and the connective tissues. In some adult tissues mitosis is almost absent, like the nervous tissue and the striated muscle tissue (skeletal and cardiac).

How does mitosis participate in the growth of multicellular organisms?
All multicellular beings grow with the increase in quantity of their cells. This increase is produced by mitosis (although some types of growth occur by cellular hypertrophy or by deposition of substances in interstitial spaces).

What is the uncontrolled mitotic process that occurs as disease in multicellular beings called?
Uncontrolled mitotic cell division is called karcinogenesis (neoplasia). Karcinogenesis occurs when a cell suffers mutations or other DNA damage, loses the ability to control its own division and the failuresis transmitted to its descendants. Cancers are malignant neoplasias. The term malignant means that neoplastic cells can disseminate to distant sites invading other organs and tissues. Neoplasias whose cells cannot disseminate to distant sites are called benign neoplasias.

Is the internal epithelium of the bowel the same as it was one month ago?
The internal epithelial covering of the intestine acts as protective barrier and also as means of nutrient absorption. The traffic of ingested material inside the intestinal lumen is very intense and the consequent tissue damage requires incessant epithelial renovation through cell division. The tissue renovation is completed in two to three days and is made by mitosis.

What is cellular regeneration? How is mitosis related to this process?
Some tissues are able to regenerate when injured. The liver, for example, regenerates when small pieces of hepatic tissue are removed, bones make new tissues in fracture regions, etc. Some animals, like planarias, are capable of regenerating their bodies when sectioned. In tissue regeneration cellular proliferation happens by mitosis.

What are centrioles? In which type of cell are they present?
Centrioles are tiny cylindrical structures made of nine microtubule triplets. They appear in pairs in the cell. Centrioles participate in the making of cytoskeleton and of cilia and flagella. In cell division they play a role in the formation of the mitotic spindle.
Centrioles are structures present in animal cells, in most protists and in some primitive fungi. There are no centrioles in cells of superior plants and in general it is considered that plant cells do not have centrioles (although this is not entirely correct since some plants have centriole-containing cells).
The region where the centrioles are located is called the centrosome of the cell.

What are the main events of the first mitotic period?
The first mitotic period is prophase. During prophase the following events occur: migration of each centriole pair (centrioles were duplicated in interphase) to opposite cell poles; aster formation around the centriole pairs; formation of the spindle fibers between the two centriole pairs.
During prometaphase the following events occur: end of chromosome condensation; disintegration of the nucleolus; breaking of the nulear envelope; dispersion of condensed chromosomes in the cytoplasm; binding of chromosomes to the spindle fibers.

What is the mitotic spindle?
Mitotic spindle is the set of aster fibers, radial structures around each centriole pair, plus the spindle fibers, fibers that extend across the cell between the two centriole pairs located in opposite cell poles. The mitotic spindle appears in prophase and has important role in the orientation and binding of chromosomes and other cellular elements causing them to separate and migrate to opposite cell poles.
Substances that disallow the formation of the mitotic spindle, like colchicine, a molecule that binds to tubulin molecules and prevents the synthesis of microtubules, interrupt cell division. Colchicine is used to study chromosomes since it paralyzes mitosis when chromosomes are condensed and so are more easily viewed under the microscope.

What are the main events of metaphase?
In metaphase the following events occur: condensed chromosomes bind (in their centromere region) to the spindle fibers and get concentrated in the middle of the cell; the formation of the mitotic spindle is completed. Metaphase ends with the breaking of the binding of identical chromatids and then anaphase begins.

What are the main events of anaphase?
In anaphase the following events occur: breaking of centromeres with separation of identical chromatids; traction (by the spindle fibers) of identical chromatids each to opposite cell poles; beginning of chromosome decondensation.

During mitotic anaphase is there separation of homologous chromosomes or separation of identical chromatids?
In the anaphase of mitosis the identical chromatids separate and complete pairs of homologous chromosomes continue to exist in each daughter cell. The separation of the homologous chromosomes occurs in the anaphase of the cell division by meiosis.

What are the main events of the final mitotic period?
The final mitotic phase is telophase. In telophase the following events occur: decondensation of chromosomes, each set located in opposite cell poles; nuclear envelope formation around each set of chromosomes forming two nuclei; destruction of the mitotic spindle; reappearing of the nucleoli; beginning of cytokinesis (the division of cytoplasm to ultimately separate the new cells).

What is the name of the cytoplasm division in the end of mitosis? What are the differences in this process between animal and plant cells?
Cytoplasm division occurs after telophase and it is called cytokinesis. In animal cells an invagination of the plasma membrane toward the cell center appears in the equator of the parent cell and then the cell is strangulated in that region and divided into two daughter cells. This type of division is called centripetal cytokinesis (from outside).
In plant cells the cytokinesis is not centripetal since the division happens from the inside. Membranous sacs full of pectin concentrate in the internal central region of the cell and propagate to the periphery toward the plasma membrane. The pectin-containing sacs fuse themselves and form a central structure called phragmoplast. On the phragmoplast cellulose deposition occurs and a true cell wall is created to separate the daughter cells. Plant cells thus present centrifugal cytokinesis.

Why is it important for chromosomes to be condensed during mitosis and decondensed during interphase?

During mitosis the main problem to be solved is the correct separation of chromosome sets between daughter cells. If chromosomes were decondensed long tiny fibers of DNA would be dispersed in cytoplasm after the karyotheca breaking and chromosomes could not be easily organized and pulled by the spindle fibers.

During interphase the function of chromosomes, i.e, of DNA molecules, is the synthesis of RNA and thus of proteins. For this task it is necessary for functional molecular regions to be decondensed (these regions form the euchromatin). During interphase in addition DNA replication occurs as a preparatory step for cell division. In this process it is fundamental for the exposition of DNA molecules to serve as templates to new DNA chains under production.

How does the quantity of genetic material vary within the cell during the sequential phases of the cell cycle?

The first period of the first phase (interphase) of the cell cycle is the G1, followed by S and G2 and then by the mitotic phase.

In G1 the quantity of DNA molecules in the cell can be represented by the formula 2n (n is the number of DNA molecules in a gamete cell of a given species), each chromosome has one chromatid. In S DNA duplicates and the quantity of genetic material is 2n, but each chromosome has two chromatids. In G2 that quantity is constant: 2n. After the mitotic phase the quantity of genetic material is 2n in each daughter cell, but each chromosome has one chromatid.

Concerning their final products (daughter cells and their ploidies) what are the differences between mitosis and meiosis?

In mitosis one cell, for example, with 2n chromosomes, duplicates its chromosomal set and divides generating two other cells, each with 2n chromosomes too. In meiosis, one diploid cell (2n) duplicates its chromosomes too, but four cells with n chromosomes are generated.

Concerning their biological function what is the difference between mitosis and meiosis?

The main biological function of mitosis is cellular multiplication, a fundamental process for the growth and development of multicellular organisms, tissue renewing, asexual reproduction, etc. The biological function of meiosis is gamete formation (in gametic meiosis) or spore formation (in sporic meiosis), i.e., the production of cells qualified for sexual reproduction with half the quantity of chromosomes compared to the original cell.

For the biological diversity is mitosis or meiosis the more important process?

Meiosis is the cell division process that allows the formation of gametes to sexual reproduction, with separation of each chromosome of the individual homologous pairs. These gametes can merge promoting combination of homologous chromosomes from different individuals. In that manner the chromosomal recombination provided by meiosis and sexual reproduction creates individuals with dissimilar genetic patrimony from their fathers and mothers and thus promotes biological diversity.

Meiosis then is the cell division process that in conjunction with genetic mutations is responsible for the biological diversity.

Why is meiosis important for the maintenance of the normal quantity of chromosomes of a species with sexual reproduction?

A reduction to a half of the maximum normal quantity of chromosomes is mandatory in some phase of the life cycle of a species that reproduces sexually. If that could not happen in each generation, whenever a zygote is formed by fusion of gametes there would be duplication in the quantity of chromosomes in a geometric progression.

Do humans present sexual spores or gametes?
Gametes are also cells with half the number of chromosomes of the normal cell of the species, but they are specialized in the fusion with another gamete that generates the zygote, a cell with double the number of chromosomes than gametic cells.
In humans as well in most animals the meiosis is gametic. There are no spores nor alternation of generations. The male gamete is the sperm cell, and the female gamete is the egg cell.

What are the two divisions of meiosis? What are the main events that occur in those divisions?
Meiosis is divided into first meiotic division, or meiosis I, and second meiotic division, or meiosis II. During meiosis I the separation of homologous chromosomes occurs, with formation of two haploid cells. In meiosis II there is separation of identical chromatids of each of the two haploid cells created in meiosis I, giving birth to four haploid cells.
Meiosis II is a process identical to mitosis.

In which meiotic division does the separation of the homologous occur? What are the ploidies of the generated cells after the end of that process?
The separation of the homologous chromosomes occurs in the first division of meiosis, or meiosis I. After the end of this cell division two haploid cells are made, each having different chromosomes (with no set of homologous). Note that in the cells generated after meiosis I each chromosome is still duplicated since the homologous chromosomes were separated.

In which meiotic division does the separation of identical chromatids occur?
The separation of identical chromatids occurs in the second meiotic division, or meiosis II. After this cell division (similar to mitosis and that does not alter ploidy) the cells are still haploid (they have become haploid after meiosis I).

How many cells are made after meiosis I and meiosis II?
After meiosis I two cells with already separated homologous are created. After meiosis II four cells are created.

What are the periods of the first meiotic division?
Meiosis I is divided into prophase I, metaphase I, anaphase I and telophase I.

In which period of meiosis does the pairing of homologous chromosomes occur?
The pairing of homologous chromosomes is a vital step for meiosis because the accuracy of the homologous separation depends on the process. This event occurs in prophase I of the cell division.

What is crossing over? In which period of meiosis does this event occur?
Crossing over is the eventual exchange of non-sister chromatids of homologous chromosomes. The phenomenon occurs in prophase I when homologous chromosomes are paired. Crossing over is of great importance for evolution and biodiversity since it provides recombination of alleles (of different genes) linked in the same chromosome during cell divison by meiosis.

What are the "chiasms" of homologous chromosomes seen in prophase I?
Chiasms are intersections of two tracts in the form of X.
The chiasms seen in prophase I are chromosome arms crossing over same arms of their homologous. In fact when chiasms are seen under the microscope chromatids are exchanging chromosomal segments with other chromatids of its homologous.

Is there interphase again between meiosis I and meiosis II?
There is no interphase nor DNA duplication between the divisions of meiosis. Only a short interval called interkinesis occurs.

What are the periods of the second meiotic division?
Meiosis II is divided into prophase II, metaphase II, anaphase II and telofase II.

What are the respective functions of the separation of homologous chromosomes and of the separation of identical chromatids in meiosis?
The separation of homologous chromosomes in meiosis I has two main functions: to reduce to a half the total number of chromosomes, generating haploid daughter cells at the end of the process, and to make possible genetic recombination since the separation is aleatory, i. e., each pair of daughter cells can be different from the other pair relating chromosomal combination from paternal and maternal origins. (And if crossing over is considered each of the four resulting cells can be different from the others.)
The separation of identical chromatids in meiosis II has the same function it has in mitosis: to separate the chromosomes already duplicated to the daughter cells.

What is the genetic code?
Genetic code is the key for the conversion of DNA nucleotide sequences (and thus RNA nucleotide sequences) into amino acids sequences that will compose proteins.

Which is the biological molecule that contains the genetic information that is transmitted hereditarily and controls the cellular functioning?
The hereditary molecule that controls the cellular functioning is the DNA (deoxyribonucleic acid). The DNA contains information for protein synthesis in cells.

How are the concepts of DNA, gene, proteins and characteristics of living beings related?
Characteristics of organisms depend on chemical reactions that occur in them. These reactions are catalyzed by enzymes, highly specific proteins. Every protein of an organism is made from information contained in RNA molecules that are made according to a template sequence of nucleotides of a DNA chain.
A gene is a DNA polynucleotide sequence that contains information for the production of a protein, rRNA, tRNA, snRNA and others untranslated RNA molecules.

What is the role of messenger RNA and ribosomes for the protein synthesis?
The mRNA is produced within the cellular nucleus and migrates to the cytoplasm where associated to ribosomes it guides the building of amino acid sequences that will compose proteins. Ribosomes are sites for the meeting and binding of mRNA and transfer RNA (tRNA), they are the structures where amino acids transported by tRNA are united by peptide bonds forming polypeptide chains (proteins).

Of what subunits are ribosomes are made?
Ribosomes are made of two subunits, the small subunit and the large subunit. These subunits are made of ribosomic RNA (rRNA) and proteins. Ribosomes have three binding sites, one for mRNA and two for tRNA.

How different are the location of ribosomes in eukaryotic and in prokaryotic cells?
In prokaryotes ribosomes are found free in cytoplasm. In eukaryotic cells they can also be found free in cytoplasm and mainly adhered to the external membrane of the rough endoplasmic reticulum.

How is the finding of ribosomes inside mitochondria and chloroplasts explained?

It is a strong hypothesis that mitochondria and chloroplasts were prokaryotes that associated to primitive eukaryotic cells under mutualism (gaining protection and offering energy). This explains why within those organelles there are DNA and protein synthesis machinery, including ribosomes. This hypothesis is known as the endosymbiotic hypothesis on the origin of mitochondria and chloroplasts.

What are some examples of human cells that produce proteins for exportation? Which cytoplasmic organelle is expected to be well-developed and abundant in those cells?
Specialized cells of the glands, like the Langerhans cells of the pancreas (that produce insulin) or the saliva-producing cells, are examples of secretory cells. In cells specialized in secretion, the endoplasmic reticulum and the Golgi apparatus are well-developed since they participate in the storage and processing of proteins for exportation.

Which are the more abundant ribosomes in secretory cells - the free cytoplasmic ribosomes or those associated with the rough endoplasmic reticulum?
Free cytoplasmic ribosomes are more related to protein production for internal cellular consumption while those adhered to the rough endoplasmic reticulum are more important in protein synthesis for exportation. Proteins made by adhered ribosomes enter the rough endoplasmic reticulum and are later transferred to the Golgi apparatus. So in secretory cells ribosomes adhered to the endoplasmic reticulum are more notable.

Where in eukaryotic cells does mRNA synthesis occur? To where do these molecules migrate?
Messenger RNA molecules are synthesized within the nucleus, pass through pores of the nuclear membrane and gain the cytoplasm to reach the ribosomes where protein synthesis occurs.

After the fact that it is based on information from mRNA what is the process of protein synthesis called?
Protein synthesis is called translation (of genetic information into proteins).

What is the difference between transcription and translation?
Transcription is the name given to the formation of RNA molecules from an open DNA chain used as a template. Translation is the making of polypeptides (amino acids bound in sequence) and thus of proteins based on information encoded in the mRNA molecule.
In eukaryotic cells transcription occurs in the nucleus and translation occurs in ribosomes. Transcription precedes translation.

How do nucleotides of mRNA chains encode information for the formation of the amino acids sequences of a protein?
There are only four types of nitrogen-containing bases that can compose RNA nucleotides: adenine (A), uracil (U), guanine (G) and cytosine (C). Amino acids however are 20 different ones. Considering only one nucleotide (a 1:1 coding) it would be impossible to codify all amino acids.
Considering two nucleotides there would be an arrangement of 4 elements, 2 x 2, resulting in a total of only 16 possible codifier units (4 x 4). Nature may know combinatory analysis since it makes a genetic code by arrangement of the 4 RNA bases, 3 x 3, providing 64 different triplets (4 x 4 x 4).
So each triplet of nitrogen-containing bases of RNA codifies one amino acid of a protein. As these triplets appear in sequence in the RNA molecule, sequential amino acids codified by them are bound together to make polypeptide chains. For example, a UUU sequence codifies the amino acid phenylalanine, as well the UUC sequence; the ACU, ACC, ACA and ACG sequences codify the amino acid threonine; and so on for all possible triplet sequences and all other amino acids.

What is the name of an RNA sequence that codifies one amino acid?

Each sequence of three nitrogen-containing bases of RNA that codifies one amino acid is called a codon. The codon is the codifier unit of the genetic code.

Since among the 64 codons of mRNA 61 codify amino acids that form polypeptide chains what are the functions of the three remaining codons?

Since there are 20 amino acids and 64 possibilities of mRNA codons, it is expected some amino acids to be codified by more than one codon. And that really happens.

Not all 64 codons however codify amino acids. Three of them, UAA, UGA and UAG, work on information that the last amino acid of a polypeptide chain under productions was already bound, i.e., they signal the end of the polypeptide synthesis. These codons are called terminal (stop) codons. The codon AUG codifies the amino acid methionine and at the same time it signals the beginning of the synthesis of a polypeptide chain (it is an initialization codon).

In prokaryotic cells there is a sequence called in general AGGAGG) in the position that antecedes the.

What is the cellular structure to which mRNA molecules bind to start the protein synthesis?

To make proteins mRNA molecules necessarily associate to ribosomes. Ribosomes have two sites for the binding of two neighboring mRNA codons and where anticodons of tRNA bind by hydrogen bond. Thus ribosomes are the structure responsible for the positioning and exposure of mRNA codons to be translated. In ribosomes the peptide bond between two amino acids brought by tRNA molecules also occurs. The peptide bond happens when tRNAs carrying amino acids are bound to exposed mRNA codons.

How are amino acids brought to the cellular site where translation takes place? What is an anticodon?

Amino acids are brought to ribosomes by RNA molecules known as transfer RNA, or tRNA. One tRNA associated to its specific amino acid binds by a special sequence of three nucleotides to a mRNA codon exposed in the ribosome. This sequence in the tRNA is known as anticodon. The tRNA anticodon must be complementary to the mRNA codon to which it binds, according to the rule A-U, CG. The ribosome then slides along the mRNA molecule o expose the following codon to the binding of other tRNA. When amino acids corresponding to neighboring codons bind by peptide bond the first tRNa is liberated.

How many of the same proteins are made at the same time by each ribosome in the translation of one mRNA molecule? How does consecutive protein production occur in translation?

Ribosomes do not make several different proteins simultaneously. They make them one after another.

Along one single mRNA molecule however many ribosomes may move in a real mass manufacturing of the same protein. The unit made of many ribosomes working upon the same mRNA molecule is called polysome.

An mRNA molecule codifies only one type of protein?

Eukaryotic cells have monocistronic mRNA, i.e., each mRNA codifies only one polypeptide chain. Prokaryotes can present polycistronic mRNA.

At the end of the assembling of amino acids into a polypeptide chain, the mRNA, by one of its terminal codons, signals to the ribosome that the polypeptide is complete. The ribosome then liberates the produced protein. In prokaryotes after this conclusion the information for the beginning of the synthesis of another different protein may follow in the same mRNA.

If a fragment of nucleic acid has a nucleotide sequence TAC can one assert that it is a codon or an anticodon?

A nucleic acid having a TAC sequence surely is not tRNA, it is DNA since RNA does not present the nitrogen-containing base thymine. Since it is not RNA it cannot be a codon or an anticodon.

Why can the genetic code be qualified as a "degenerate code"?
The genetic code is a degenerate code because there are amino acids codified by more than one type of codon. It is not a system in which each element is codified by only one codifying unit.
For example, the amino acid arginine is codified by six codons: CGU, CGC, CGA, CGG, AGA and AGG.

What is the concept of universality of the genetic code? What are the exceptions to this universality?
The genetic code is universal because the rules of protein codification based on mRNA codons are practically the same for all known living beings. For example, the genetic code is the same for humans, for bacteria and for invertebrates.
The protein synthesis in mitochondria, chloroplasts and some protozoans however are accomplished by different stop (termination) codons.

How does the universality of the genetic code make the recombinant DNA technology possible?
The universality of the genetic code refers to the fact that all living beings have their protein synthesis machinery functioning according to the same principles of storage, transmission and recognition of information, including translation of mRNA codons. This fact makes possible the exchanging of genes or gene fragments between different organisms and secures that these genes continue to command protein synthesis.
This universality, for example, makes feasible the insertion of a fragment of human DNA containing a gene for the production of a given protein into the genetic material of bacteria. Since the bacterial transcription and translation systems work in the same manner as the correspondent human systems do, the bacteria will begin to synthesize the human protein related to the inserted DNA fragment. There are industries that produce human insulin (for use by diabetic patients) in this way, synthesized by bacteria with modified DNA. If the genetic code was not universal this kind of genetic manipulation would be impossible or very difficult to accomplish without new technological progresses.