SUMMARY OF THE COURSE

in master's programme Biomedical Engineering
Course 166.142 Biology

Old exam questions collection

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TECHNISCHE
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Contents

1 AF (Andreas Farnleitner)

1.1 Bacteria, Archaea

1. **Difference between gram positive and gram negative?**

   These categories are based on their cell wall and the following reaction ot the Gram stain test. Gram positive bacteria have a plasma membrane, a pheriplasmatic space and a thick peptidoglycan layer. Gram negative bacteria form very complex cell walls whit a Plasma membrane, a pheriplasmatic space, a thin peptidoglycan layer and another pheriplasmatic space and a outer outer lipid membrane. By the test the Gram positive bacteria become a blue colour the Gram negative bacteria got red/pink.

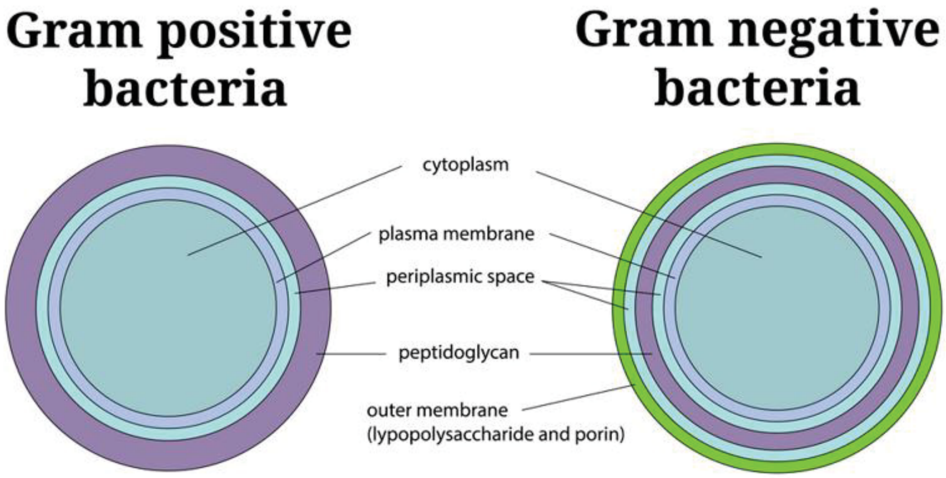

Figure 1: Difference between gram positive bacteria and negative one.

2. **Definition of prokaryotes**

   Any of various microorganisms of the domains Archaea and Bacteria, characterized by the absence of a distinct membrane-bound nucleus and membrane-bound organelles and by the simultaneous occurrence of DNA transcription and protein synthesis at the same site, in contrast to eukaryotes. They were originally defined in contrast to eukaryotic cell morphology and are based on the relatively simple cell structure and morphology (very pragmatic use).

3. **Size of bacteria, virus, protein**

   Bacterium 1-2 μm diameter 5-10 μm length

   Virus diameter between 20-300 nm

   Protein 3-6 nm Cell sizes at 0,15 μm are the borderline

4. Draw the different shapes of Bacteria (coccus, bacillus, morphologies etc.)

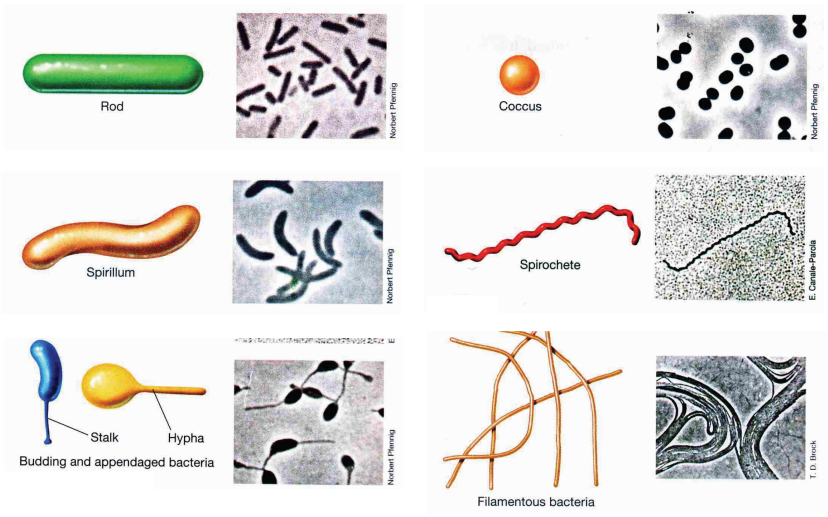

Figure 2: Shape and Size – “form follows function”.

5. Bacteria intracellular structures.

Bacteria are prokaryotes, lacking well-defined nuclei and membrane-bound organelles, and with chromosomes composed of a single closed DNA circle.

Consist of:

a) Plasma membrane

b) Ribosome

c) Nucleoid and Plasmids

d) Periplasmatic space

e) Capsules slime layers

f) Cell wall

g) Pilli

h) Flagella

i) Endospore

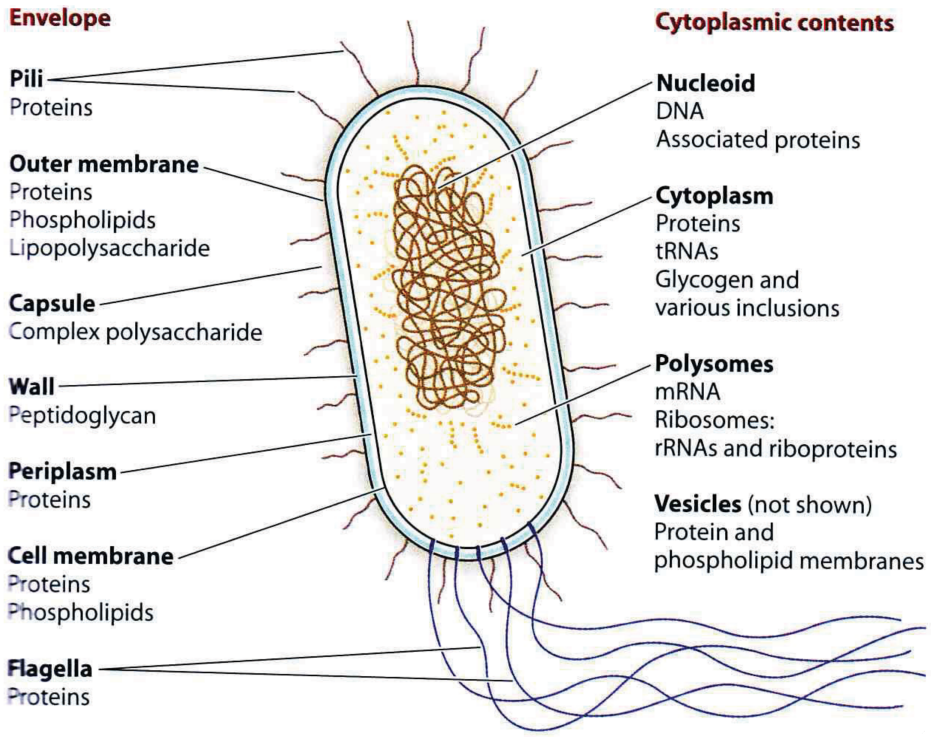

Figure 3: Structure of a prokaryotes.

6. **What is a plasmid? Determine max. 3 sentences.**

   Is a small double stranded DNA molecules that exist independently of the chromosome. His shape is linear or circular and he has generally less than 30 genes. They have the ability to replicate autonomously.

1.2 Subcellular Infectious Agents

1. **Prions. What are they? How do they propagate information?**

   Prions is an infectious agent composed of protein in a misfolded form. They propagate themselves by making conformational changes in other molecules of the same type of protein. This contrasts with all other known infectious agents (virus/ bacteria/ fungus/ parasite) which must contain nucleic acids. They are infectious agents composed of a protein in a misfolded form, which is able to transmit their misfolded shape onto normal variants of the same type of protein/amino acid chain.

   This change affects the behaviour of the protein. While this represents a transfer of information, prion interactions leave the sequence of the protein unchanged and so are not technicals considered an exception of the central dogma. All known prion diseases affect the structure of the brain or other neural tissue and all are currently untreatable and universally fatal.

2. **What is a viroid**

   Viroids are plant pathogens that consist of a short stretch (a few hundred nucleo-bases) of highly complementary, circular, single-stranded RNA - without the protein coat typical for viruses. Viroid RNA does not code for any protein. The replication mechanism involves RNA

polymerase II, an enzyme normally associated with synthesis of messenger RNA from DNA, which instead catalyzes "rolling circle" synthesis of new RNA using the viroid's RNA as template.

3. **What is a transposon. Give an example in humans and it's function and impact.**

   Transposable elements are sequences of DNA that can move or transpose themselves to new positions within the genome of a single cell. The mechanism of transposition can be either "copy and paste" or "cut and paste". Transposition can create phenotypically significant mutations and alter the cell's genome size.

   Example "Alu element":
   An Alu element is a short stretch of DNA originally characterized by the action of the Alu restriction endonuclease. It causes several inherited human disease and various forms of cancer.

4. **Retrovirus**

   A retrovirus is a virus that uses RNA as its genetic material. When a retrovirus infects a cell, it makes a DNA copy of its genome that is inserted into the DNA of the host cell. There are a variety of different retroviruses that cause human diseases such as some forms of cancer and AIDS (Acquired ImmunoDeficiency Syndrome).

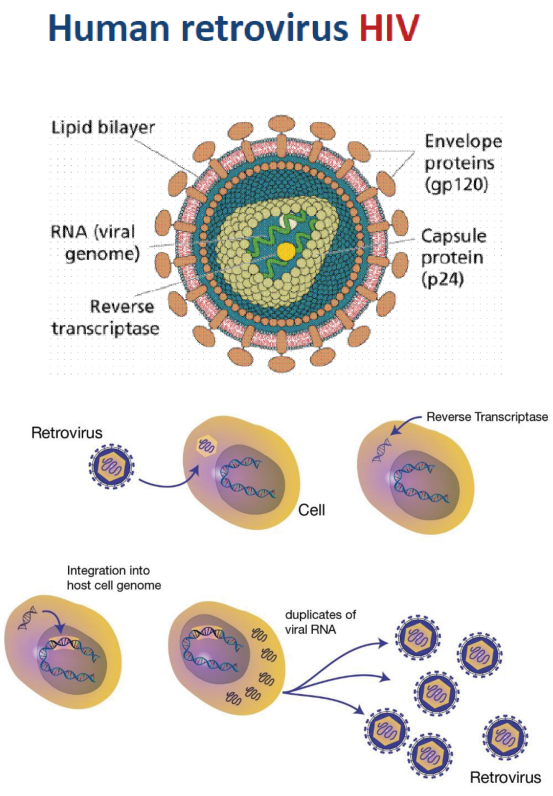

Figure 4: Structure of a the Human retrovirus (HIV).

5. **On what is the Baltimore classification of viruses based on; give an example?**

The Baltimore classification of viruses is based on the mechanism of mRNA production. Viruses must generate mRNAs from their genomes to produce proteins and replicate themselves, but different mechanisms are used to achieve this in each virus family.

Example: Double stranded DNA (dsDNA) viruses
A double stranded DNA virus enters the host nucleus before it begins to replicate. It makes use of the host polymerases to replicate its genome and is therefore highly dependent on the host cell cycle.

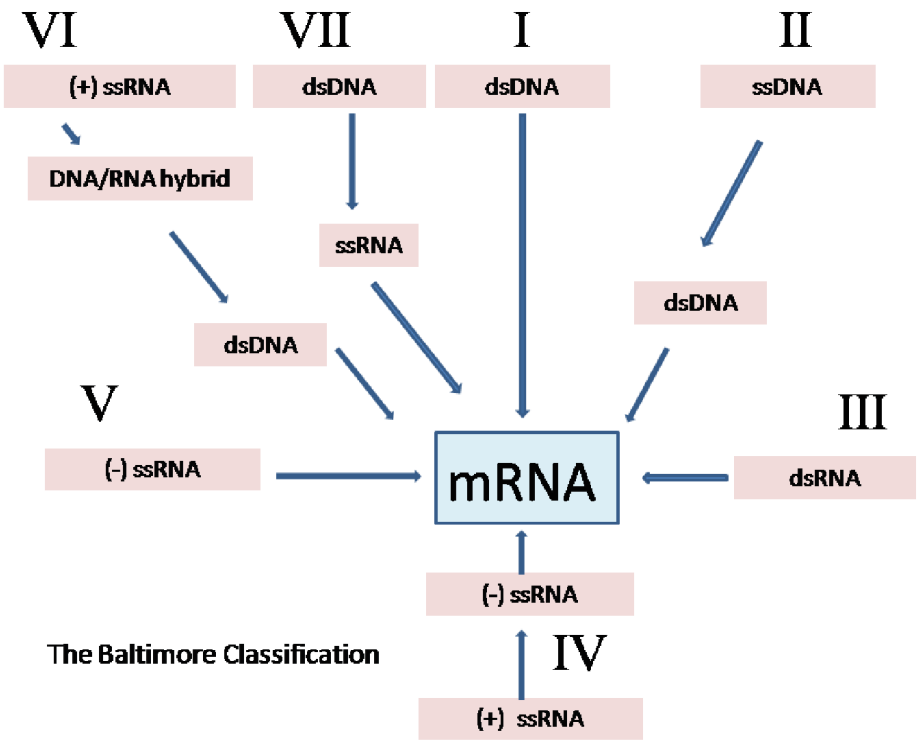

Figure 5: Baltimor classification tree.

6. **What are Poisonous, Toxic or Hazardous substances?**

In daily life substances are considered P-T-H that can represent threat during “usual” exposure. The actual observed tic/harmful effects result always from two major components: determination of toxicity and the organism /biological system itself.

7. **Define the term “Intoxication"**

Intoxication is the harm caused by a chemical substance to the considered organism.

8. **Define the term “Infection"**

Infection is the entry, development or multiplication of an infectious agent in the organism.

9. **Define the term “Disease"**

   A disease are symptoms of illness in a host and can be a result of intoxication or infection.

10. **Explain the genomic dynamics in viruses. How dynamics can result in new pathogenic strains of human influenza.**

    Viruses can undergo genetic change by:

    Genetid drift individual bases in the DNA or RNA mutate to other bases.

    Antigenic shift major change in the genome of the viruses. This can be a result of recombination or re-assortment.

11. **What is a viruses?**

    A virus is a small infectious agent that can replicate only inside the living cells of organisms. Viruses infect all types of organisms and can be found in almost every ecosystem on earth.

    Virus particles consist of two or three parts:

    - The genetic material made from either DNA or RNA.
    - A protein coat (capsid) that protects these genes.
    - An envelope of lipids that surrounds the protein coat when they are outside a cell.

    The shapes of viruses range from simple helical and icosahedral forms to more complex structures. The average virus is about 1/100 the size of the average bacterium. Most viruses are too small to be seen directly with a light microscope.

1.3 Toxicology

1. **Define the term "RISK" for human health according to the World health organisation (WHO).**

   RISK is the likelihood of hazard causing harm in exposed populations in a specified time frame including the magnitude of that harm.

2. **Define the field of toxicology with a maximum of two sentences**

   Toxicology is the study of the adverse effects of chemical or physical agents on living organism (human and animals) environmental health. The Society need chemicals, so it is important to assess (*Bewerten*) the potential hazard of this chemicals, this make the toxicology to an important part of thee decision-making process (*Entscheidungsprozess*).

3. **Define the therm "HAZARD" for human health according to the World health organisation (WHO).**

   HAZARD is a (biological), chemical, physical or radiological agent that has the potential to cause harm.

4. **What is the principle procedure to assess eco-toxicological risk? Maximum 4 sentences.**

(EU TGD Part II, 2003)

Hazard identification the first step is to identify the effects of concern and to establish or review the hazard classification of the substance.

Dose (concentration) – response (effect) assessment the predicted no-effect concentration (PNEC) is developed.

Exposure assessment environmental concentrations (PECs) are determined either by using/collecting environmental monitoring data or by modelling exposure in a hypothetical standard environment.

Risk characterisation the last step encompasses the risk characterisation in which the PEC and PNEC values are used to develop a risk characterisation ratio which needs to be below 1.

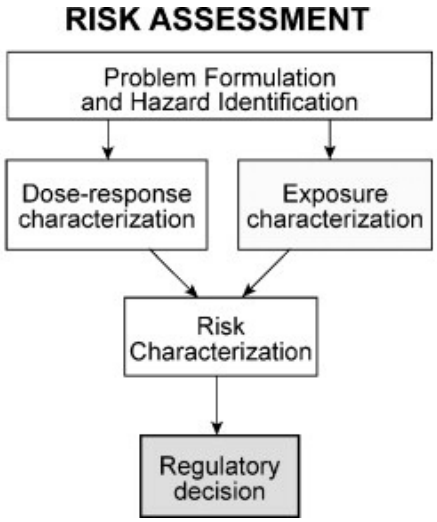

Figure 6: Ecotoxicological Risk Assessment steps.

5. **What are the principal characteristics (give 3 examples) of Tumour? What means metastasis (explain with no more than 3 sentences)?**

Generally definition tumour	Malignant (*bösartig*) tumour
excessive not coordinated focally autonomous	infiltration destruction metastasis

Metastases are similar daughter tumours that are spatially separated from a primary tumour and that develop through the transfer of living tumour cells. Metastases are the most frequent cause of death form cancer.

6. **Name at least five effects and "endpoints" of toxicity.**

Acute toxic	Subacute to chronic exposure	Environmental harmful
very toxic - toxic - harmful corrosive irritation	sensitization and allergy hormone-active other organ toxicity non-organ directed toxicity • mutagenic • cancerogenic • teratogenic	-

7. **Name at least five effects of toxicity on humans.**

   See answer before.

8. **List the major determinants contributing to the toxicity of a substance and describe very shortly (few words).**

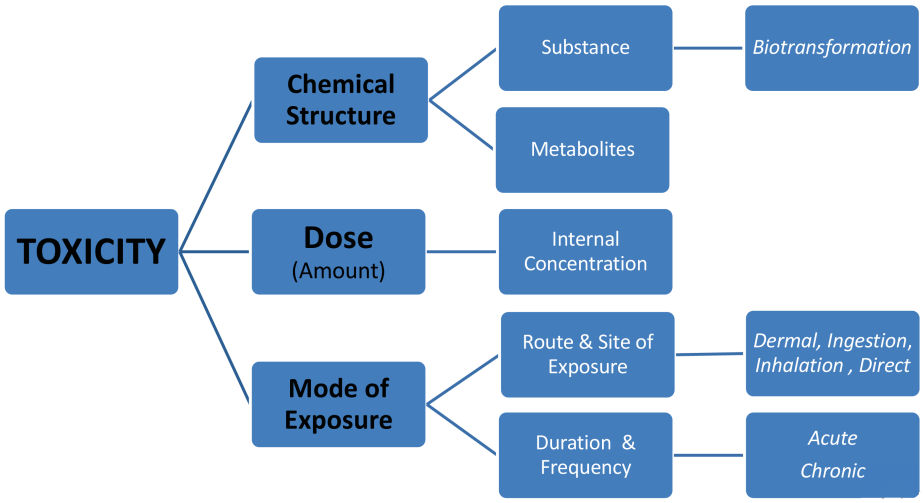

Figure 7: The 3 fundamental determinants of toxicity's.

9. **Explain the principle of dose-response relationships.**

   Dose-response relationship is the scientific basis for the derivation of health-based guideline values for substances. It is the relationship of the dose (concentration) of the hazard, which is exposed, to the effect on the target. Dose-response relationships shows the relationship between the absorbed does and the resulting effect. This relationship can be linear or non-linear and depends on a lot of factors (mode of application, frequency of exposition, target, ...).

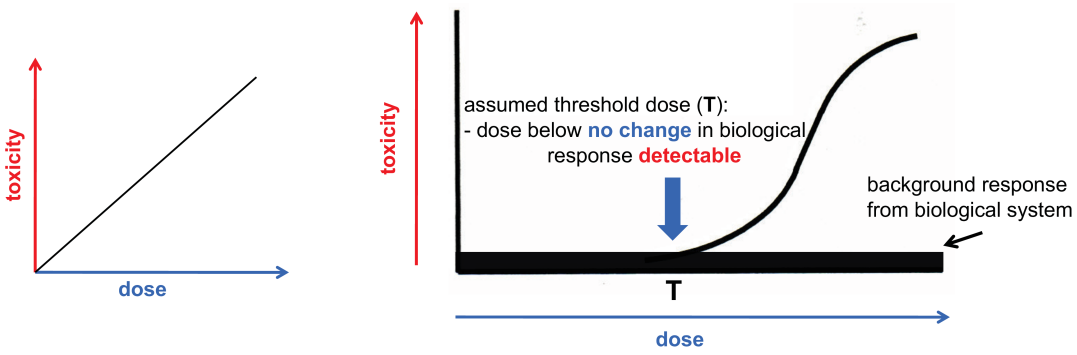

Figure 8: left non-threshold model for genotoxic carcinogens; right Toxic agents with assumed threshold level.

2 AMA (Astrid Mach-Aigner)

2.1 Biotechnology

1. **White biotechnology:**
   a) **To what application field is this term related?**
   b) **What relevance has white biotechnology within all biotechnological application fields (minor, middle or major)?**
   c) **Mention 4 products/types of whit biotechnology (except biofuels)**
   d) **Explain the six steps of cellulosic ethanol production. Name the organism, which is used for the fermentation. Which bottlenecks. Which alternative strategies.**

a) Industrial production processes

b) Middle to Major

c)

- Food and feed
  - Chee's, bread
  - Beer, wine
  - Silage
- Bulk and fine chemicals
  - Alcohols, acids
  - Vitamins, amino acids
  - Cosmetics
  - Enzymes

d)

a) Pretreatment of lignocellulose feedstock
b) Cellulose hydrolysis
c) Separation of sugar solution form residues
d) Ethanol fermentation

e) Distillation for 95% pure EtOH

f) Dehydration for > 99% pure EtOH

For fermentation we use baker's yeast. The yeast can not metabolic the 5-carbon sugars derived from the hemicellulose but only the glucose that comes form the cellulose part. The alternative can be a use of other microorganisms.

2. **Green biotechnology: earliest application, transgenic plants, biological pest control**

   The earliest application was about 1960 where rice, wheat and maize varieties were introduced. There are 3 Application fields:

   - plant and animal breeding: includes controlled pollination and cross-breeding
   - transgenic plants: to increase yield and quality and improve resistance and tolerance
   - biological pest control: to reduce the pest populations by natural enemies

3. **Name 6 categories of biotechnology according to the colour, what type of application they are related to, and mention one example each.**

Name	Application type	Example
Red Biotechnology	Pharmaceuticals and medical processes	Penicillin
Green Biotechnology	Agriculture	Plant and animal breeding
White Biotechnology	Industry	Biofuels
Grey Biotechnology	Waste treatment	Wastewater treatment
Brown Biotechnology	Environment	Bioremediation
Blue Biotechnology	Maritime resources	marine Bacteria as a source of anti-cancer-drug

4. **Name the 6 colours. Which section? And give one example for each.**

   See answer before.

5. **Name 4 of the first (approx 5000 years old) biotechnological enterprises.**

   a) brewing beer

   b) baking bread

   c) tanning leather

   d) producing vinegar

6. **Four examples for old biotechnology**

   See answer before.

7. **What is bioremediation? Which pollutants are targets? What are the main sources of these pollutants?**

   It is the use of organisms to remove pollutants from ecosystems. They target Benzol, xylol, toluol, CHCs, TNT, PAHs. The main sources of the pollutants are:

- Benzol $\longrightarrow$ Petrol
- Xylol $\longrightarrow$ Production of plastics
- Toluol $\longrightarrow$ Production of glue

8. Name 4 biological achievement that took place between the 14th and 20th century.

a) Vinegar production
b) Isolation of microorganisms
c) Microscope
d) Penicillin discovered

9. Biofuels

Biofuel is a source of renewable energy, unlike fossil fuels such as petroleum, coal, and natural gas. Biofuel is any fuel that is derived from biomass. As biomass we can use plant or algae material or animal waste. Since such feedstock material can be replenished readily.

Some example of biofuels are:

- Biodiesel
- Green diesel
- Bioethanol

10. What is the difference 1nd, 2nd, 3nd and 4nd generation biofuel. Explain 2nd generation biofuel and there advantages.

Generation	Feedstock (*Rohstoff*)	Production method	Advantages
1	Food crops (e.g. soybean)	Fermentation, Hydrolysis	(disadvantage Fuel vs Food)
2	Non-food crops (e.g. Wood)	Fermentation, Hydrolysis, Gasification	No fuel vs food, increase 'net energy gains', more cost competitive
3	Algae, Microbes	Fermentation, Hydrolysis, Gasification	wide range of different fuels, saving water resources, reduction of farmland
4	Other sources (e.g Modified algae)	Fermentation, Hydrolysis, Gasification	carbon negative production process

11. What are 2nd generation biofuels? What is the advantage?

See answer before.

12. Red Biotechnology:

a) To what application field is this term related?
b) What importance does it have in biotechnology (minor, middle, major)?
c) Name 3 products of red biotechnology (except antibiotics).

d) Penicillin: Name the production microorganism. Explain the mode of action shortly. Why are half-synthetic penicillins used?

a) Pharmaceuticals and medical processes.

b) Major.

c)

- Plavix
- Diovan
- Nexium

d)
The production microorganism is the fungus Penicillium.
Penicillin inhibits the production of cell walls by bacteria by binding and inactivating proteins present in the bacterial cell wall. This prevents growth and eventually kills the bacteria due to osmotic damage because they are not protected by their outer wall. In addition, the cell wall of the bacteria disintegrates (*auflösen*) when it attempts to divide.
Half-synthetic penicillins are used to avoid human allergies and bacterial resistance and to enhance their effectiveness also against gram-negative bacteria.

13. Describe how penicillin is produced/synthesized.

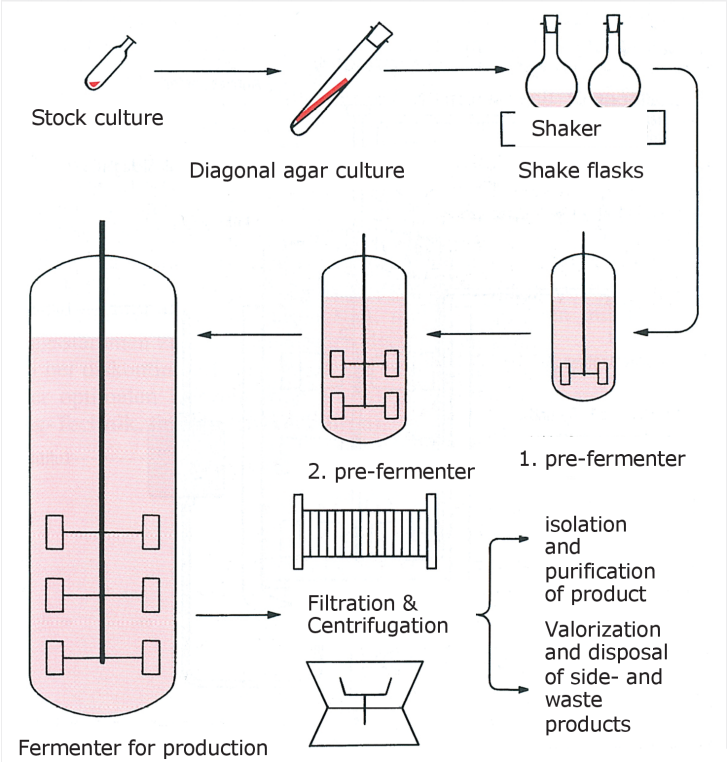

Figure 9: Production steps of penicillin.

14. **Bioaugmentation: Example by naming microorganism, substance, gene of impact**

    Bioaugmentation describes the introduction of microorganisms as starter cultures into soil material or water. In this process, the bacteria and other organisms function as the basis for raising a culture medium. The aim is to stimulate an unliving (contaminated) soil or water to metabolism by means of a rinsing agent. (*Anm.: Aquarium Starter, sonst ersticken die Fische.*)

3 HH (Heidrun Halbwirth)

3.1 Introduction to Biology and the origin of life

1. **What is life? Give your definition an and explain.**

   Life is matter that can reproduction itself and evolves as survival dictates.

   For biologists life is a characteristic of organisms that exhibit all of the following phenomena:

   a) Order
   b) Adaptation
   c) Metabolism
   d) Growth and Development
   e) Response to stimuli
   f) Reproduction
   g) Homeostasis

2. **What do organism on earth consist of?**

   Living systems are composed of non-living molecules (mainly CHNOPS-elements – Carbon, Hydrogen, Nitrogen, Oxygen, Phosphorus and Sulphur. Carbon is the basic building block of organic substances.

3. **Why to study biology? How do discoveries in biology influence every day life?**

   Biology helps us to understand the living world and the way how species function, evolve and interact. Biology influences our every day life by the advances in medicine, agriculture and biotechnology

4. **Define science and biology. What disciplines are linked to biology?**

   Science (latin. scientia = knowledge) = is a systematic enterprise that builds and organizes knowledge in the form of testable explanations and predictions about the universe.

   Biology the study of life and living organisms (part of the Live Sciences, which is one of the two major branches of natural sciences).

   Disciplines linked to biology:
   Biology often overlaps with other sciences like

   - biochemistry and toxicology -> chemistry and medicine
   - biophysics -> physics
   - astrobiology -> astronomy

5. **Explain the terms physical evolution, chemical evolution and biological evolution.**

Physical evolution starts whit Bigbang. Origin of the earth and oceans formation. Heavy bombardment of meteorites.

Chemical evolution formation of complex biomolecules, Vesicles and Protobionts.

Biological evolution life emerges in the first form out of LUCA (Last Universal Common/Cellular Ancestor).

6. **Is extraterrestrial life possible? Define terrestrial life and explain your answer.**

Yes, extraterrestrial life is possible.

Terrestrial life (latin: Terra = Erth) mean all parts of life that toke place on the earth.

Sufficient quantities of carbon and the other major life-forming elements, along with water, may enable the formation of living organisms on other planets with a chemical make-up and temperature range similar to that of Earth. Terrestrial planets, such as Earth, are formed from "stardust" in a process that allows for the possibility of other planets having formed with compositions similar to Earth's.

7. **What is habitable zone and why it is important. What is Kepler project?**

Habitable zone is the distance from a star where an earth-like planet can maintain liquid water on its surface and potentially earth-like life.

The Kepler Project was a search conducted by NASA to discover comparatively small planets and thus potentially habitable extrasolar planets. The Kepler space telescope was used to search for them. Extrasolar planets are planets that are located in another solar system.

8. **Describe Miller-Urey Experiment of 1952. What has been demonstrated and how did it influences our modern understanding of the origin of life?**

Stanley Miller, together with his colleague Harold Urey, simulated an Earth's atmosphere as it probably existed before the formation of living matter. To do this, he introduced a gas mixture consisting of water, methane, ammonia, hydrogen and carbon monoxide into a glass bulb system. In this glass system there were several physical sections: an electric arc to simulate lightning, a heat source to simulate evaporation and a cooler to simulate rain. After some time, the resulting mixture was examined: large amounts of organic molecules were found in it, e.g. alanine, lactic acid, acetic acid, urea.

The experiment demonstrates that biomolecules can form in earth like conditions and that the primitive earth may even have favoured the synthesis of biomolecules.

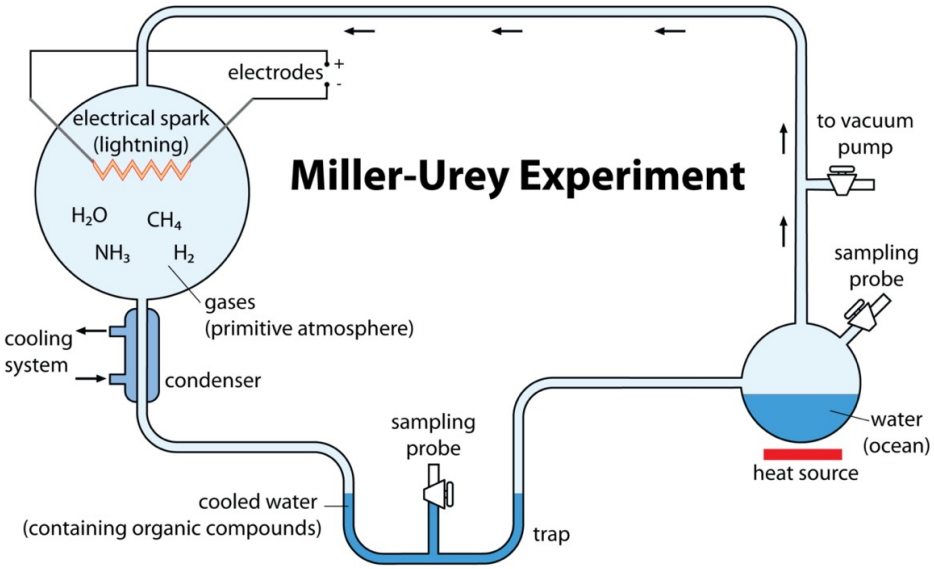

Figure 10: Setup of the experiment.

9. Where did life originate?

For a long time, the primordial ocean was said to be the place where life originated. Based on new research results, this area can now be narrowed down further. Life arose in the area of submarine hydrothermal vents, which spewed hydrogen rich molecules and their rocky nooks (*Nischen*) could have provided mineral catalysts for critical reactions.

10. Explain the cell theory.

The cell is the fundamental unit of life, and that all living things are composed of one or more cells or the secreted products of those cells.

11. Explain the cell theory in its modern interpretation?

The generally accepted parts of modern cell theory include:

a) All known living things are made up of one or more cells.

b) All living cells arise from pre-existing cells by division.

c) The cell is the fundamental unit of structure and function in all living organisms.

d) The activity of an organism depends on the total activity of independent cells.

e) Energy flow (metabolism and biochemistry) occurs within cells.

f) Cells contain DNA which is found specifically in the chromosome and RNA found in the cell nucleus and cytoplasm.

g) All cells are basically the same in chemical composition in organisms of similar species.

12. Explain the theory of evolution

It is a central organising concept in biology, implying that life changes and develops through evolution and that all life forms known have a common origin.

13. Explain the four levels of protein structure; which structure determines the function of a protein?

Primary structure refers to the linear sequence of its amino acid structural units.

Secondar structure consists of local inter-residue interactions mediated by hydrogen bonds, or not. The most common structures are alpha helices, beta sheets and random coil.

Teritary structure is the three dimensional conformation of a polypeptide stabilized by intramolecular bonds, which form between amino acids in the polypeptide. They ionic bonds, hydrogen bonds, disulphide bonds, and Van der Waals reactions.

Quanternary structure two or more polypeptides linked together to form a single protein. All types of bonding previously mentioned are involved with quaternary proteins.

The quaternary structure is the impotents structure for determine the function of a protein.

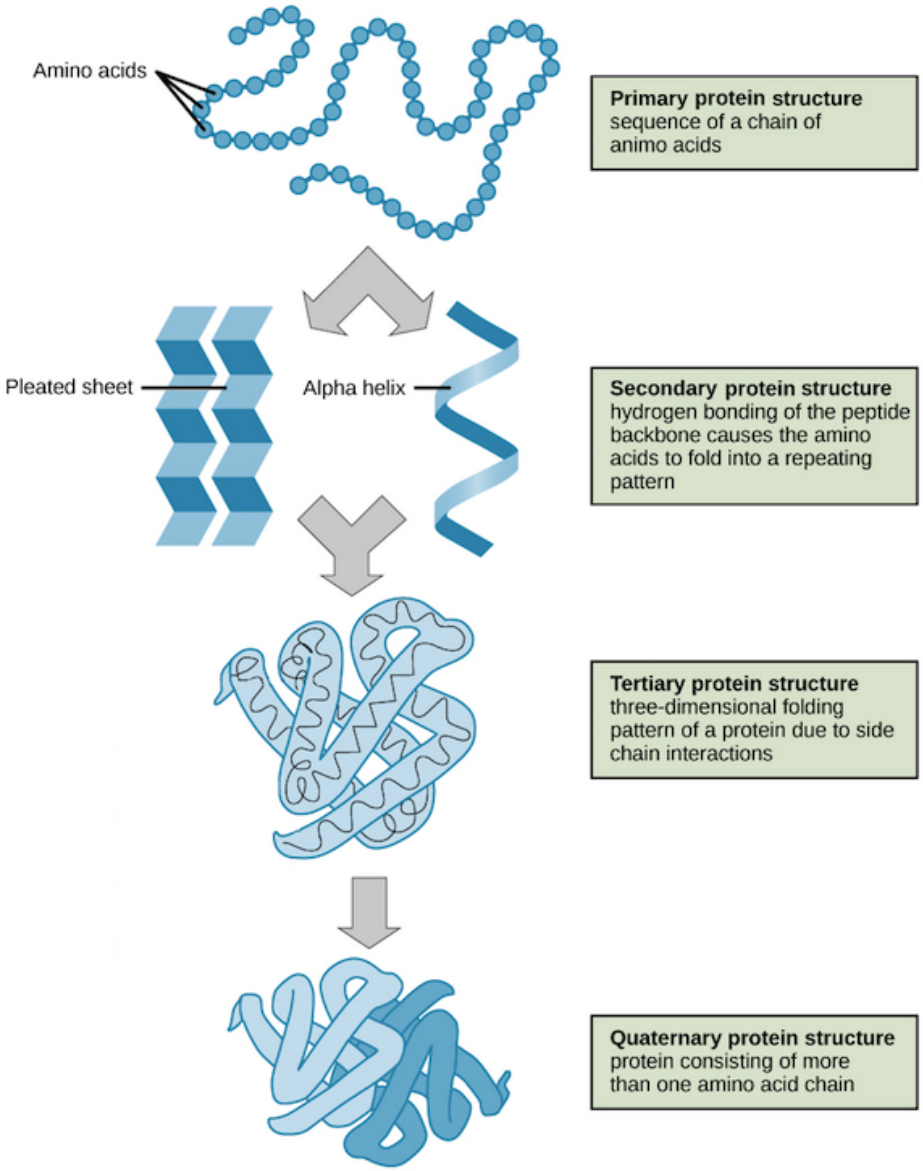

Figure 11: Setup of the experiment.

14. **Explain the gene theory.**

    A gene is a unit of heredity and corresponds to a region of DNA that influences the form or function of an organism in specific ways.

15. **Why are deep sea hydrothermal vents important for studying the origin of life?**

    Because life might have originated from these vents, in which an early form of metabolism, where a cycle of chemical reactions released energy that was able to be harnessed by other processes, took place.
    The synthesis of amino acids could have occurred deep in the earth's crust, they were then brought up into cooler waters where the presence of clay minerals would have led to the formation of peptides and protocells. The hypothesis is supported by the fact that, Methane (CH4) and Ammonia (NH3) were not present in the vents, in contrast to the earth's primitive atmosphere.

3.2 Evolution

1. **Darwinism: core set of theories**

    a) Theory of the evolution of the species
    b) Theory of a common descent
    c) Theory of the multiplication of species
    d) Theory of gradualism
    e) Theory of natural selection

2. **Darwin´s four postulates**

    a) Individuals within species vary.
    b) Some of these variations are heritable.
    c) More offspring are produced than can survive.
    d) Survival and reproduction are non-random.

3. **Evolutionary development by genetic drift**

    Genetic bottlenecks and founder events cause the development of a new generation out of a relatively small number of individuals (decimated by chance/earthquake/human influence etc. or migration). It is aimless, not adaptive and reduces variety of genes.

4. **What happens during RNA replication? In which cases can it be found in Nature?**

    RNA replication is the copying of one RNA to another (doesn't need proteins for that) and it is a special flow of information. Viral RNA polymerase copies plus-sense genomic RNA into complementary minus-sense RNA and new minus sense strands serve as template for new plus-sense strands. Many viruses replicate this way. The enzymes (RNA-dependent RNA polymerases) are also found in many eukaryotes where they are involved in RNA silencing.

5. Chromosome mutations: Mechanisms and significance for evolution.

A mutation is basically a permanent change in the genetic material. It can be triggered by mutagens such as UV radiation or viruses. It can also arise spontaneously during DNA replication or meiosis. One type of mutation is the so-called chromosomal mutation.

A chromosomal mutation is a structural change in one or more chromosomes. In contrast to point mutations, chromosomal mutations are larger structural changes in which the sequence of genes on the chromosomes changes. If the changes occur in somatic cells (*Körperzellen*), they can be passed on to daughter cells via mitosis (= somatic mutation). If the changes affect germ cells (*Keimzellen*) (sperm, egg cells), then they can be passed on to the next generation (= germline mutations).

It gives five types of chromosomal mutations. The first two are particularly important for evolution.

Duplication one section of the chromosome is duplicated because a broken apart section has been integrated into the sister chromatid.

Inversion within a chromosome, a piece can reinsert itself in the other direction after a double break.

Deletion a part of the chromosome is lost.

Insertion here, a chromosome has an extra part.

Translocation chromosomes can break apart and lose fragments that become attached to the chromatid of another chromosome.

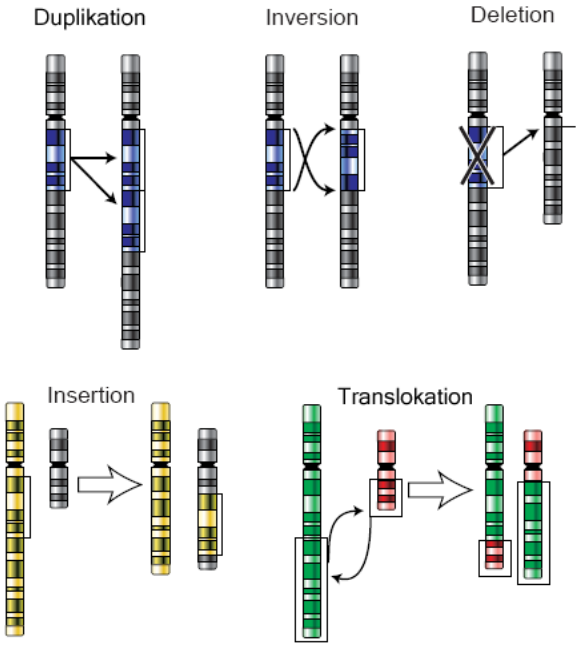

Figure 12: Scheme of chromosomal mutations.

6. Describe the four basic mechanisms of change and the main sources of genetic variation.

Evolutionary factors are processes that lead to changes in the allele frequencies in the gene pool of a population. According to the synthetic theory of evolution, these processes are the cause of all evolutionary changes.

Migration of individuals in and out of different populations of a species. This results in an exchange between the individual gene pools of the populations.

Mutation a spontaneous change in the base sequences of the DNA continuously gives rise to new hereditary (*Erbanlagen*) dispositions. If a mutation takes place in a cell that later gives rise to germ cells (*Keimzellen*), the altered genetic material is transferred to the next generation and thus changes the gene pool of the population. The new genetic material leads to characteristics that did not previously occur in the population. Hereditary traits (*Erbanlagen*) that lead to disadvantageous characteristics disappear from the gene pool or remain rare.

Natural selection occurs through the nature of the environment. The condition for selection is the variability in a population caused by recombination and mutation. Individuals with disadvantageous traits have fewer offspring than those with more advantageous traits. The individuals make a different contribution to the gene pool of the next generation due to their characteristics.

Genetic drift this is a spontaneous change in the gene pool. A natural disaster or epidemic can cause a group of individuals with a certain trait to suddenly die out. The surviving part of the population spreads out with a slightly different genetic composition.

Natural selection and genetic drift require genetic variation!

Main source of genetic variation are:

- Mutation
- Gene flow/Migration
- Sex

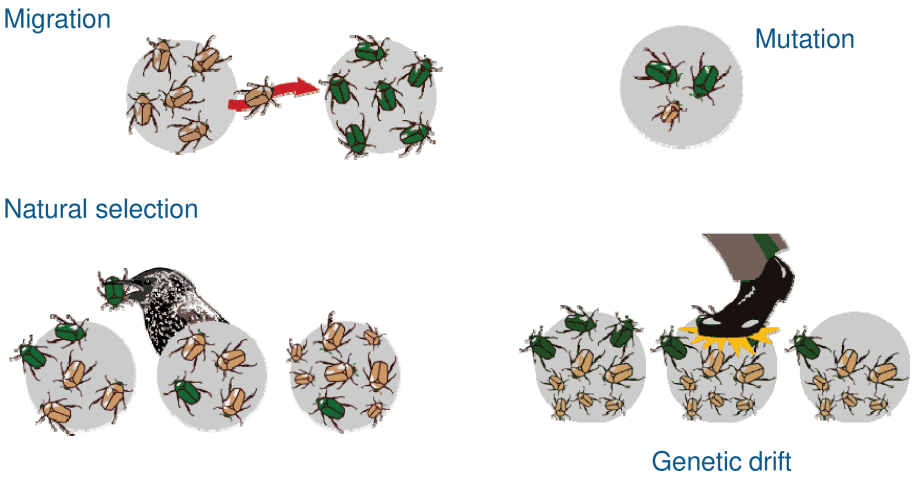

Figure 13: Four basic mechanisms of change.

7. **Describe the core set of theories of the Evolutionary biology according to Charles Darwin.**

   Biological evolution is the change of living organisms over time. Change in inherited characteristics of biological populations over time. Darwin's four postulates for biological evolution as follows:

   a) Individuals within species vary.
   b) Some of these variations are heritable.
   c) More offspring are produced than can survive.
   d) Survival and reproduction are non-random.

8. **Explain the different forms of mutation.**

   Nonsense mutation is a genetic mutation of DNA sequences resulting in a shorter, unfinished protein production.

   Missense mutaiton the change of a single base pair causes the substitution of a different amino acid in the resulting protein.

   Framshift mutation involves the insertion of deletion of a nucleotide in which the number of deleted base pairs is not divisible by three. This is significant because the cell reads a gene in groups of three.

   Insertion mutation involves the addition of genetic material. It can involve only a single extra DNA base pair or also up to a piece of a chromosome.

   Deletion mutation involves the loss of genetic material. Can be small, single missing DNA base pair, or large, piece of chromosome.

   Repeate expansion mutation 3 base pairs get repeated of one or more times.

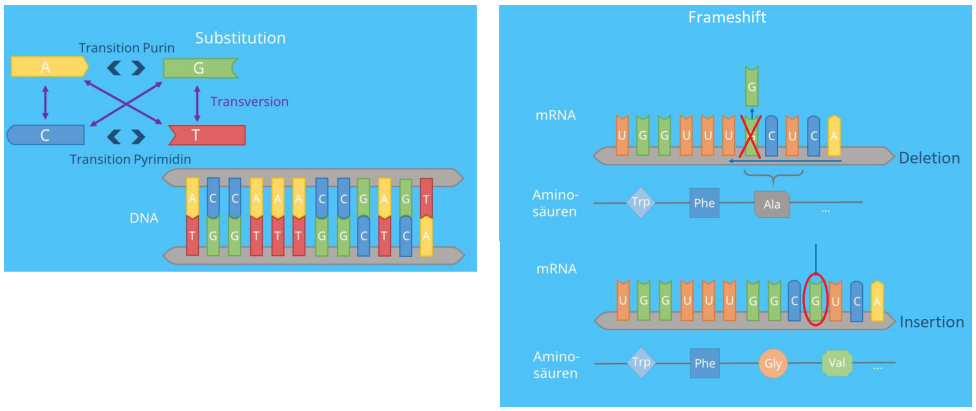

Figure 14: Gene mutations types. Transition and Transversion are Substitutions mutations. Deletion and Insertion are Framshift mutations.

9. **What are allele, chromosomes, genome?**

   Allele the different forms of expression of a gene are call allele. Many multicellular organisms have two sets of chromosomes, they are diploid. Diploid organisms have two copies of each gene and therefore one allele on each chromosome. If both alleles are the same, they are homozygotes, if they are different they are heterozygotes.

Chromosomes a chromosome is an organized structure of DNA and protein found in cells. The human has 23 chromosome pairs.

Genome the genome is the entirety of an organism's hereditary information. It is encoded either in DNA or, for many types of virus, in RNA. The genome includes both the genes and the non-coding sequences of the DNA/RNA.

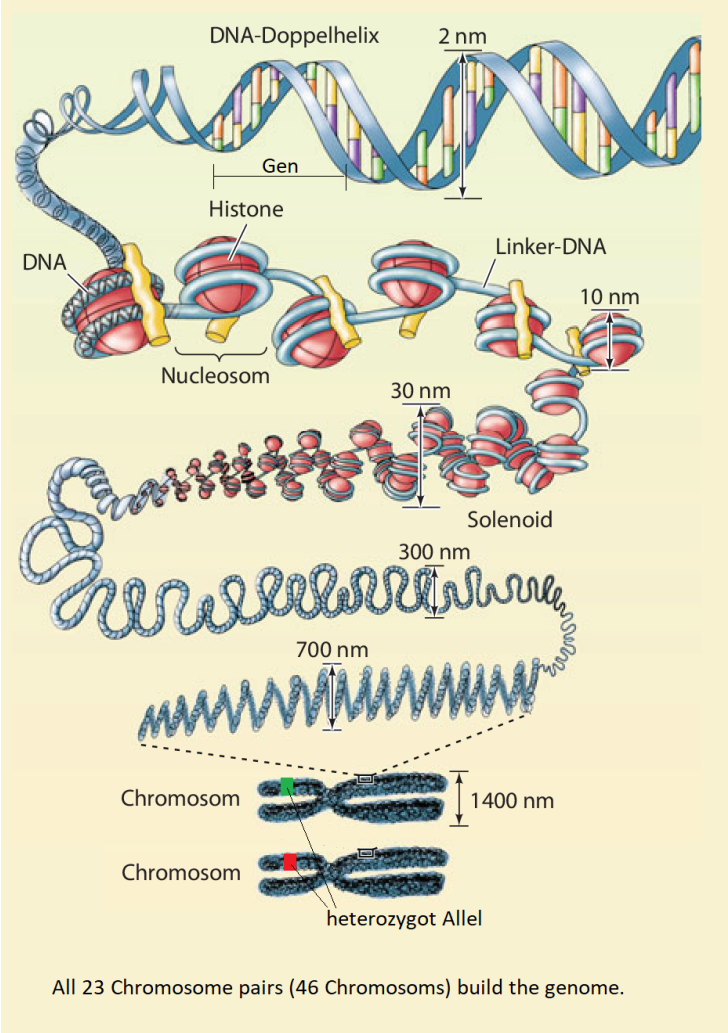

Figure 15: Structure of an chromosome.

10. Define the term macroevolution and describe supporting evidences.

Macroevolution is the change between species. All of life is connected and can be traced back to one common ancestor.

Mutation
Gene Flow
Genetic drift
Natural selection

+ 3.8 billion years = Macroevolution

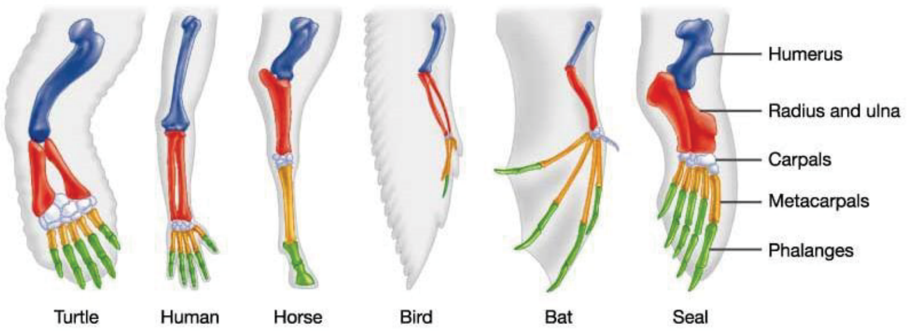

Figure 16: Evidence for common ancestors. Similarity in limb structure among animals, even if function is different evolved through natural selection.

11. Define the term microevolution. What molecular mechanisms are the driving forces?

Microevolution is the change within species. A change on the genetic level of a population. For this change is mutation, recombination and natural selection very important.

12. Gene duplication and genome duplication: Mechanisms and significance for evolution.

Name	Description	Mechanism	Significance
Gene duplication	duplication of a short stretch of DNA, creating an extra copy of the sequence	unequal crossing-over during meiosis or retrotransposition	redundant new genes may acquire new functions by mutation
Genome duplication	addition of a complete set of chromosomes	errors in meiosis or (in plants) mitosis	massive gene duplication, may create new species

13. Describe gene duplication.

Is the duplication of a short stretch of DNA, creating an extra copy of the sequence. This is caused by unequal crossing over during meiosis or retrotransposition, cDNA integrated in chromosomes.

14. Polyploidy, where is it found why is it important fo evolution?

In a cell are more than two chromosome sets. Normal case a human have 23 chromosomes by polyploidy you have 46 chromosomes ore more. In animals is this genome mutation very rare, you find this quit often in plants. Fro plants this is the key source for genetic variation. Some examples:

- Triploid (3N): banana, seedless watermelon
- Tetraploid (4N): potato, apple

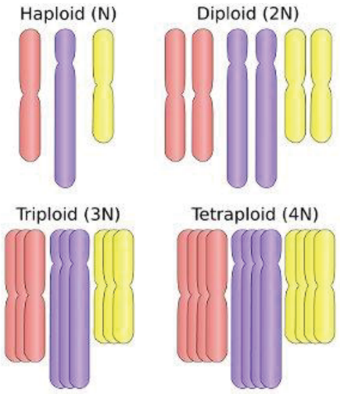

Figure 17: The prefix gives the information about sum of the chromosomes. Tri=3, Tetra=4, etc.

4 RL (Rita Barbara Linke)

4.1 Cytology

1. **Describe the different forms of the endoplasmic reticulum and give their functions?**

   Endoplasmic reticulum (ER) is organized into a net like labyrinth of branching tubules and flattened sacs that extends through the cytosol. It gives two forms of ER.

   raug ER is studded whit ribosomes and is attached to the nuclear membrane. The rough ER protein synthesises and processing.

   smooth ER he has no ribosomes. He do phospholipid biosynthesis and packaging of proteins into vesicles.

   But forms packaged her products in vesicle and transport this to the Golgi-apparatus

2. **Describe the structure of a nucleus and its substructure**
   Nucleus consists of a small spherical compartment (the nucleolus) which is the site of ribosomal biogenesis and the DNA stored as chromatin (called nucleoplasm) surrounding this nucleolus. Around this, there is the nuclear envelope – a double-layer membrane penetrated by nuclear pore complexes.

   The inner membrane of the nuclear envelope is the binding site for chromosomes and for the nuclear lamina and the outer membrane is continuous with the membrane of the ER and it is studded with ribosomes. The nuclear pore complex contains aqueous passages through which small water-soluble molecules diffuse. Each nuclear pore contains a central granule, is surrounded by a cytoplasmic ring with filaments on the outside and a nuclear ring and nuclear basket on the inside.

3. **Cell wall**

   The cell wall provides the shape and protect the cell from osmotic stress. Only bacteria, archaea, plants, fungal and algal have a cell wall. Animals and protozoa have no cell wall.

4. Compare Mitosis and Meiosis. Which goal has Meiosis?

	Occurs in	Creates	Number of cell division	Mechanism	Produce	Daughter cells are	Goal
Mitosis	all organisms (except viruses)	body cells	1	No recombination or crossing over	2 diploid daughter cells	identical	produce two cell nuclei whit full chromosome set
Meiosis	animals, plant and fungi	sex cells	2	recombination/ crossing over in prophase	4 haploid daughter cells	genetically different	transfer of genetic material through reduction of the chromosome set (products gametes or spors)
Both	-	new cells	-	follow same staps	begin with one parent cell	-	-

5. Name 3 elements of the cytoskeleton.

- Actin filaments, make the membrane of the cell tougher (*zäher*)
- Microtubules, absorb strain (*Druck*) and are transport routes
- Intermediate filaments, provide tensile strength

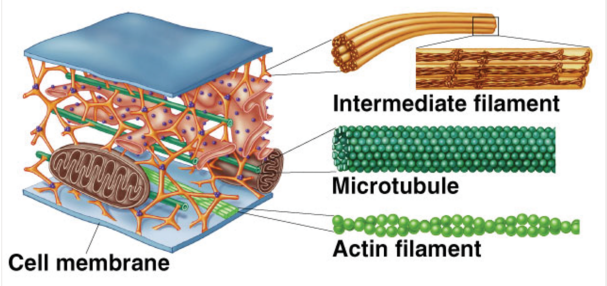

Figure 18: The tree major components of the cytoskeleton.

6. What are the tree major components of the cytoskeleton?

See answer before.

7. **Which organisms have cell walls? Name at least 4 compounds of cell walls.**

   Only bacteria, archaea, plants, fungal and algal have a cell wall. The cell wall consist, among others, of the following components:

   a) Protein
   b) Peptidoglycan (prokaryotic)
   c) Cellulose (plants)
   d) Chitin (fungal)

8. **Name five different organelles of a eukaryotic cell and briefly describe the function of each.**

   Ribosome are located in the cytoplasm or to the ER and are involved in the production of proteins.

   Endoplasmatic reticulum (ER) central role in the synthesis of export proteins, membrane proteins and membrane lipids.

   Golgi apperatus the substances produced by the cell itself are chemically labelled and prepared for transport to other organelles or for export out of the cell.

   Lysomsome contain digestive enzymes and are involved in intracellular digestion of food particles, disease causing bacteria and worn out cell parts.

   Vacuole in plants they act as storage organelle for both nutrients and waste products and are the easiest way of increasing cell size. In unicellular organisms they are relevant for moment and maintaining osmotic pressure.

   Mitochondria "Powerhouse of the cell" supply the cell with energy, which it needs for movement and growth.

   Chloroplast are organelles that only occur in the cells of plants and algae. They are specialised in converting the energy of sunlight into chemical energy.

9. **Name five organelles of the cell + function.**

   See answer before.

10. **2 cellular organelles with DNA: where are found and functions.**

    The only organelles whit DNA are found in eukaryotic cells. The different of both of this is the cell type they are located.

    Mitochondria only found in animal cells. "Powerhouse of the cell" supply the cell with energy, which it needs for movement and growth.

    Chloroplasts only found in plants and algae cells. They are specialised in converting the energy of sunlight into chemical energy.

11. Compare a plant cell with an animal cell according to the cytology; name the major commons and differences?

	Have	Do not have
Plant cell	Cell wall, large vacuoles, chloroplast	centrioles
Animal cell	Centriole, small vacuoles	cell wall, chloroplast
Both	cell membrane, mitochondria, golgi apparatus, nucleus, cytoskeleton, ribosomes, ER, lysosomes	-

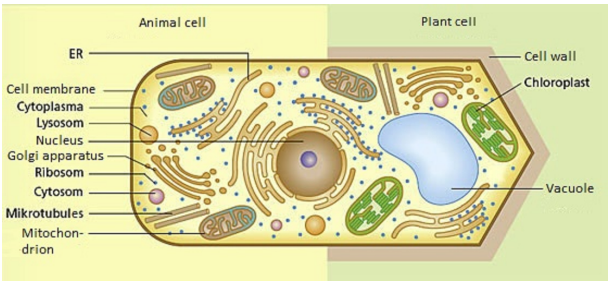

Figure 19: Schematic drawing of a eukaryotic cells. On the left side a animal cell on the right a plant cell.

12. Name differences between a prokaryotic cell and eukaryotic cell.

	Have	Do not have
Eukaryotic cell	nucleus, golgi apparatus, mitochondria, ER, etc.	nucleoid, plasmid
Prokaryotic cell	nucleoid, plasmid	nucleus, golgi apparatus, mitochondria, ER, etc.
Both	DNA, cell wall, cell membrane, cytoplasms, ribosomes, flagella	-

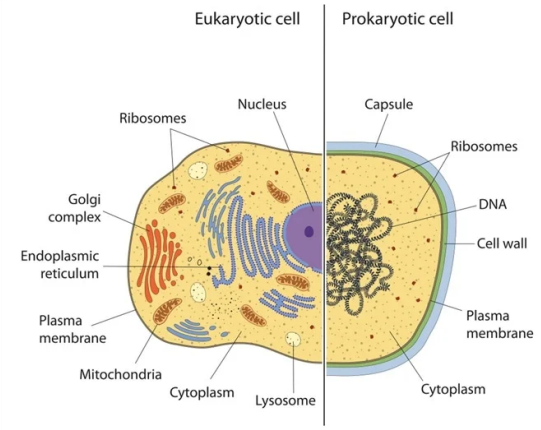

Figure 20: Schematic drawing of a eukaryotic animal cell (left) and prokaryotic cell (right).

13. Ribosome, biogenesis, structure and function.

Ribosome:
Are organelles made of RNA and protein. They are attached to the ER of float freely in the cytoplasm.

Biogenesis:
Takes place in the cell cytoplasm and in the nucleolus. Involves the function of >200 proteins in the synthesis and processing of the four eukaryotic rRNAs.

Structure:
Ribosome is an RNA-protein complexes (2/3 RNA, 1/3 protein) composed of two subunits. One small subunit and an large one.

Function:
The small subunit provides framework on which tRNAs are accurately matched to the codons of the mRNA. The large subunit catalyses the formation of the peptide bonds to link amino acids together into polypeptide chains.

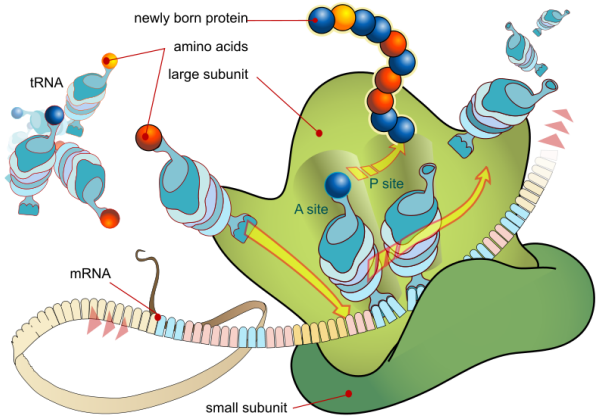

Figure 21: Schematic drawing of a ribosome.

14. Describe the major components of cell membrane and their function.

Phsophslipid form a bilayer and so the cell membrane.

Proteins for transport of products in and out of the cell.

Cholesterol for flexibility of the membrane.

15. **Draw a sketch fo a phospholipid membrane. Mention the hydrophobic and hydrophilic parts.**

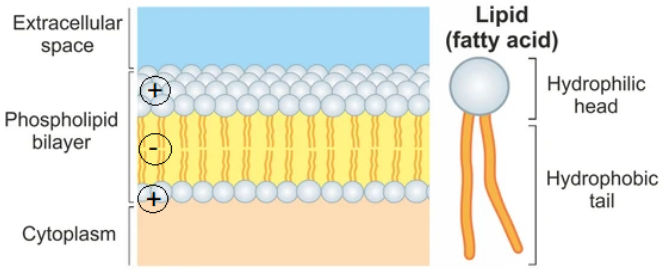

Figure 22: Schematic drawing of a cell membrane, Lipid double layer.

4.2 Genetics

1. **Mendelian Laws of Inheritance**

   The Mendelian Laws of Inheritance state that:

   Dominance in a heterozygote, one trait will mask the presence of another trait for the same characteristic and rather than both alleles contributing to a phenotype, the dominant allele will be expressed exclusively. The recessive allele will remain “latent”, but will be transmitted to offspring by the same manner in which the dominant allele is transmitted.

   Segregation each parent carries two copies of the gene (particles) that determine a single trait. When gametes are formed, the two particles separate so each gamete receives just one copy and at fertilization, each gamete donates its particle so that the zygote has two particles again.

   Independent Assortment when two traits are considered in the same cross, the segregation of one pair of alleles is independent of the segregation of the other pair of alleles. This means that when a parent is heterozygous for both genes, all four possible gamete types have an equal chance of forming.

2. **Discuss the concepts of homologous chromosomes, diploidy, and haploidy. What characteristics do two homologous chromosomes share?**

   Diploidy:
   Two sets of chromosomes are called diploid. Diploid organisms have two copies of each gene. The genetic material of an human is made out of 23 diploid chromosomes.

   Haploidy chromosomes:
   You have only one set of chromosome. Through meiosis (1+2) the diploid chromosomes sets get separated in haploid chromosomes. So you get gametes that have only one set of haploidy chromosomes.

   Homologous chromosomes:
   Homo- means "same", indicating that these chromosomes contain the same type of genetic information. In each pair, the two homologous chromosomes differ in terms of their origin. One comes from the mother, the other from the father.

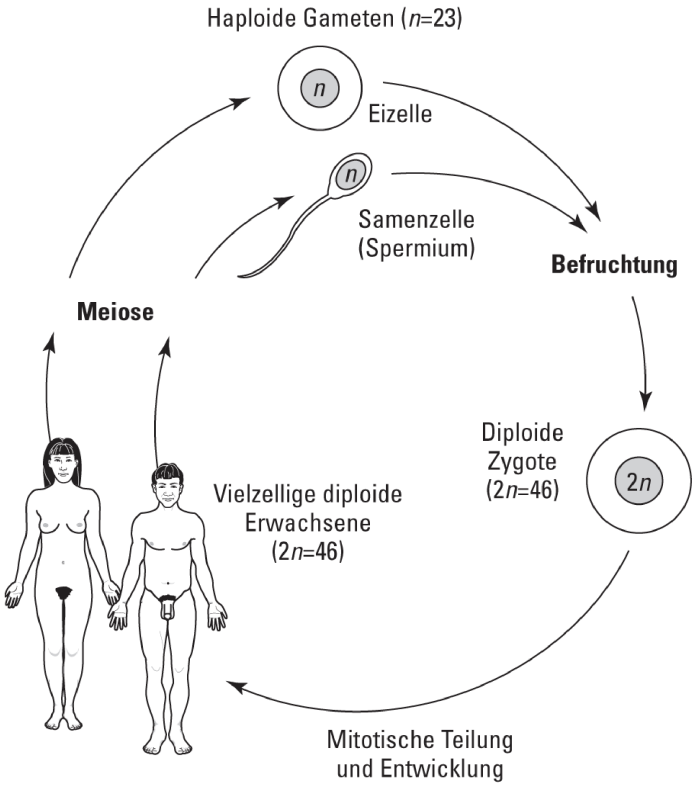

Figure 23: The human life cycle.

3. Monohybrid cross

Monohybrid crosses are Mendel's simplest crosses involving only one pair of traits and was made by mating homozygous individuals from two parent strains – each exhibiting one of two contrasting forms of the character studied.

4. Incomplete dominance

A cross between parents with contrasting traits may sometimes produce offspring that shows an intermediate phenotype -> incomplete dominance. Because neither of the alleles is dominant, the phenotypic ratio is identical to the genotypic ratio.

5. Briefly describe the haplontic life cycle.

Two organisms of opposing gender contribute their haploid germ cells to form a diploid zygote. The zygote undergoes meiosis immediately, creating four haploid cells. These cells undergo mitosis to create the organism. Many fungi and many protozoa are members of the zygotic life cycle.

6. genetic variation of meiosis compared to mitosis

Mitosis No recombination or crossing over, daughter cells are identical

Meiosis Recombination/crossing over in prophase, daughter cells are genetically different

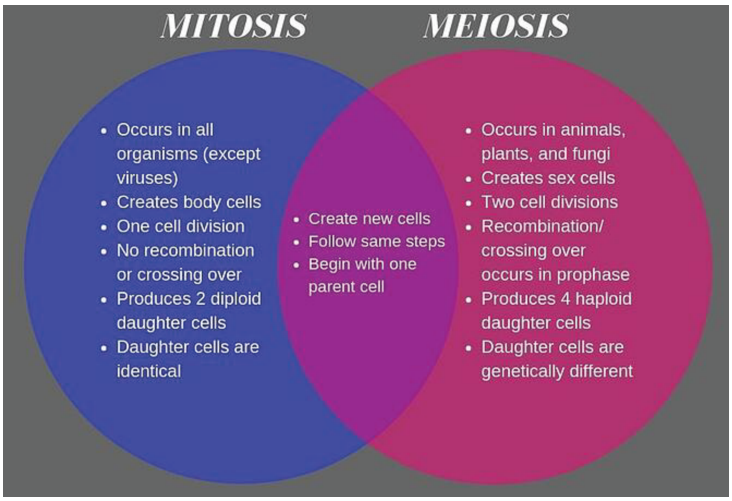

Figure 24: Cell division – Mitosis versus Meiosis.

7. Briefly describe the diplontic life cycle.

The species is diploid, grown from a diploid cell called the zygote. The organism's diploid germline stem cells undergo meiosis to create haploid gametes (the spermatozoa for males and ova for females), which fertilize to form the zygote. The diploid zygote undergoes repeated cellular division by mitosis to grow into the organism.

8. Why are we all individuals according to Mendel's law? Also give a rough calculation for that.

The two partners of a homologous chromosome are never genetically identical. The Principle of Independent Assortment leads to the genesis of all possible chromosome combinations.The number of formed gametes out of one Individual with a differing chromosome composition is 2n. For humans this means 2^{23} (approx. 8 million) possible gametes.

2n; n= 23 Chromosomes; p= 2 Parents:
$2^n = 2^{23} \approx 8 \cdot 10^6 \longrightarrow$ combinations of gametes
$(8 \cdot 10^6)^p = (8 \cdot 10^6)^2 = \underline{\underline{64 \cdot 10^{12}}} \longrightarrow$ combinations of chromosomes

$64 \cdot 10^{12}$ combinations represent a higher number of humans than people living on earth together with those having lived at any time!

9. Multiple Allele

Diploid chromosomes have on both chromosome alleles. If the alleles are the same we call it homozygote. If they are different they are heterozygotes. Alleles can also be dominant or recessive.

Mutations within one gene will change the gene product in different ways. Consequently the number of alleles within a population is not restricted to two and they can only be analysed within populations.

10. Define multiple alleles with the blood type AB0.

A and B dominate to 0; A co-dominant to B; B co-dominant to A. The dominant alleles (A and B) have a higher change to get inherited. All four Phenotypes (A, B, AB and 0) are represented by three Alleles of one single gene.

parent		potential offspring			
Phenotype	Genotype	A	B	AB	0
A x A	I^AI^0 x I^AI^0	¾	-	-	¼
B x B	I^BI^0 x I^BI^0	-	¾	-	¼
0 x 0	I^0I^0 x I^0I^0	-	-	-	alle
A x B	I^AI^0 x I^BI^0	¼	¼	¼	¼
A x AB	I^AI^0 x I^AI^B	½	¼	¼	-
A x 0	I^AI^0 x I^0I^0	½	-	-	½
B x AB	I^BI^0 x I^AI^B	¼	½	¼	-
B x 0	I^BI^0 x I^0I^0	-	½	-	½
AB x 0	I^AI^B x I^0I^0	½	½	-	-
AB x AB	I^AI^B x I^AI^B	¼	¼	½	-

Figure 25: Possible Phenotypes of offspring of parents in all combinations of AB0-blood groups.

11. Explain the dihybride cross according to Mendel's Laws. Draw a Punnet square analysis.

The dihybrid cross is explained in Mendel's 3 Law of Independent Assortment. This principle states that when two traits are considered in the same cross, the segregation of one pair of alleles is independent of the segregation of the other pair of alleles.

This means that when parent is heterozygous for both genes, all four possible gamete types have an equal chance of forming.

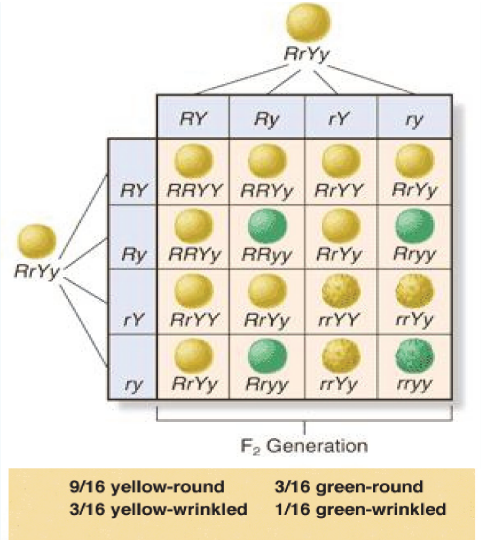

Figure 26: Punnet square cross for pea. In the F1 generation every pea is yellow and round. In the F2 generation the predicted ratio is 9:3:3:1.

12. What does x-linked (sex-linked) inheritance mean, give a typical example for human beings?

Phenotypic expression of an allele located on the sex chromosomes of an individual (X or Y). Differs from the inheritance of autosomal traits where both sexes have the same probability of inheritance. Sex linked inheritance varies from the Mendelian ratio of 3:1 by having males a 50:50 chance of inheriting the characteristic if located on the X chromosome.

Example:
Recessive X-linked genetic disorder – haemophilia A (*Bluterkrankheit*)

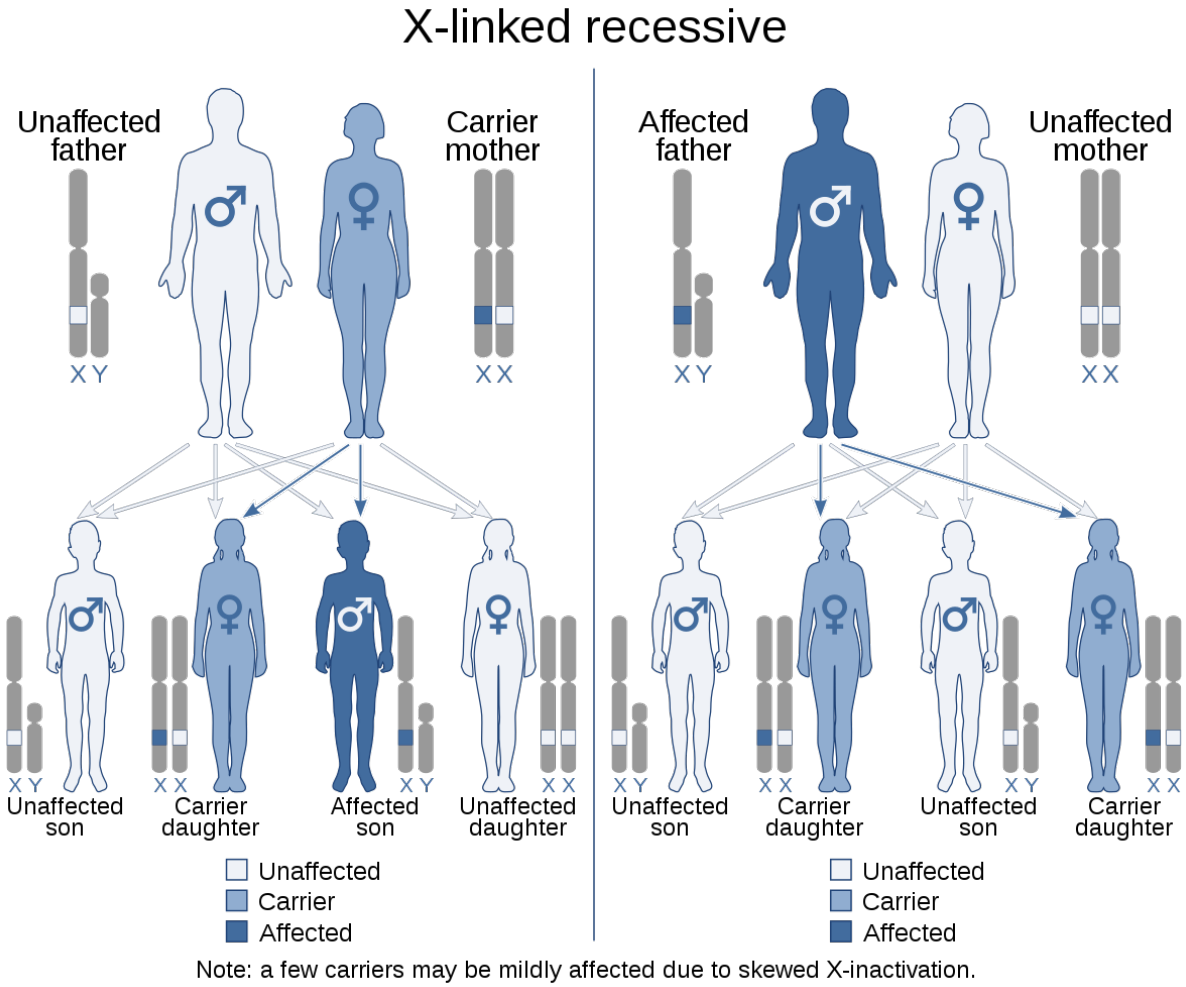

Figure 27: X-linked recessive inheritance.

13. Cell division - Mitosis

Is a part of the cell cycle when replicated chromosomes are separated in two separate nuclei. Outcome of mitosis are two genetically identical daughter cells.

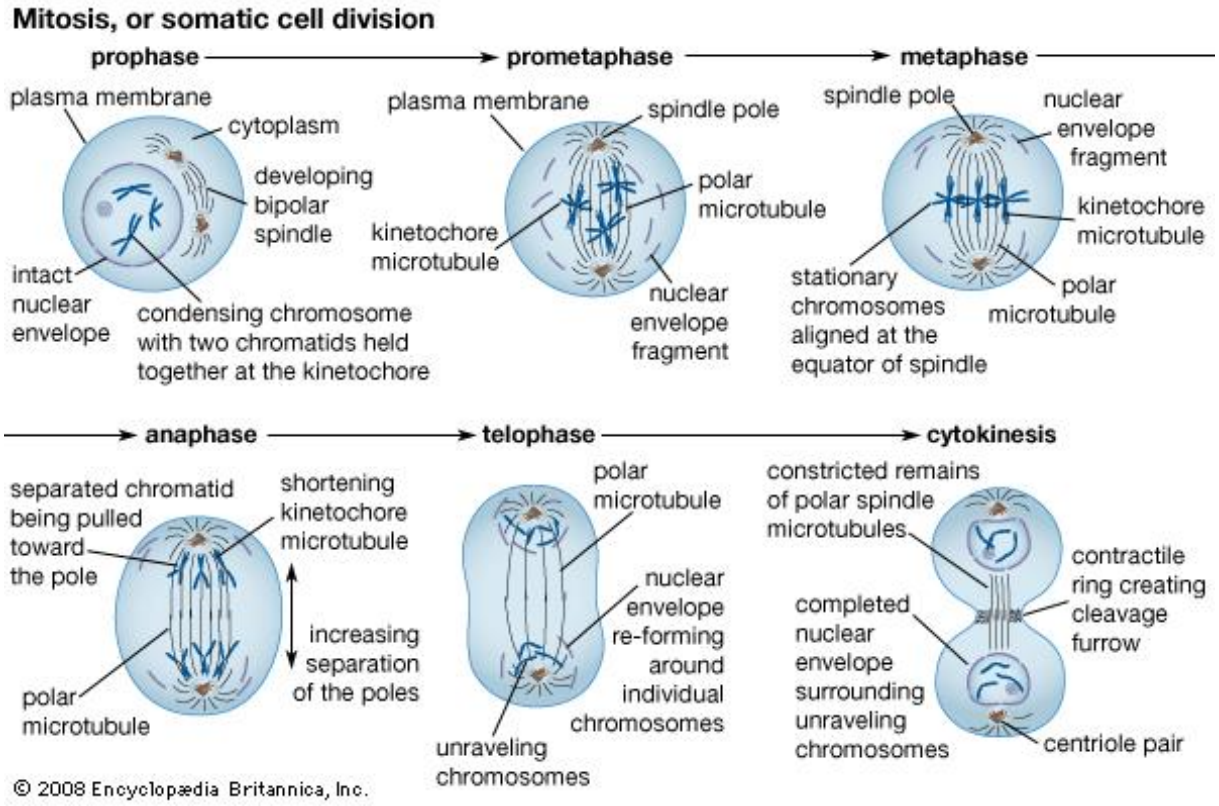

Figure 28: Description of the single steps there mitosis.

14. Cell division - Meiosis

Meiosis is a special type of cell division necessary for sexual reproduction. Chromosomes in meiosis undergo a recombination process which shuffles the genes and produce a different genetic combination in each gamete. Outcome of the meiosis is four genetically unique haploid cells (in animals sperm and egg cells).

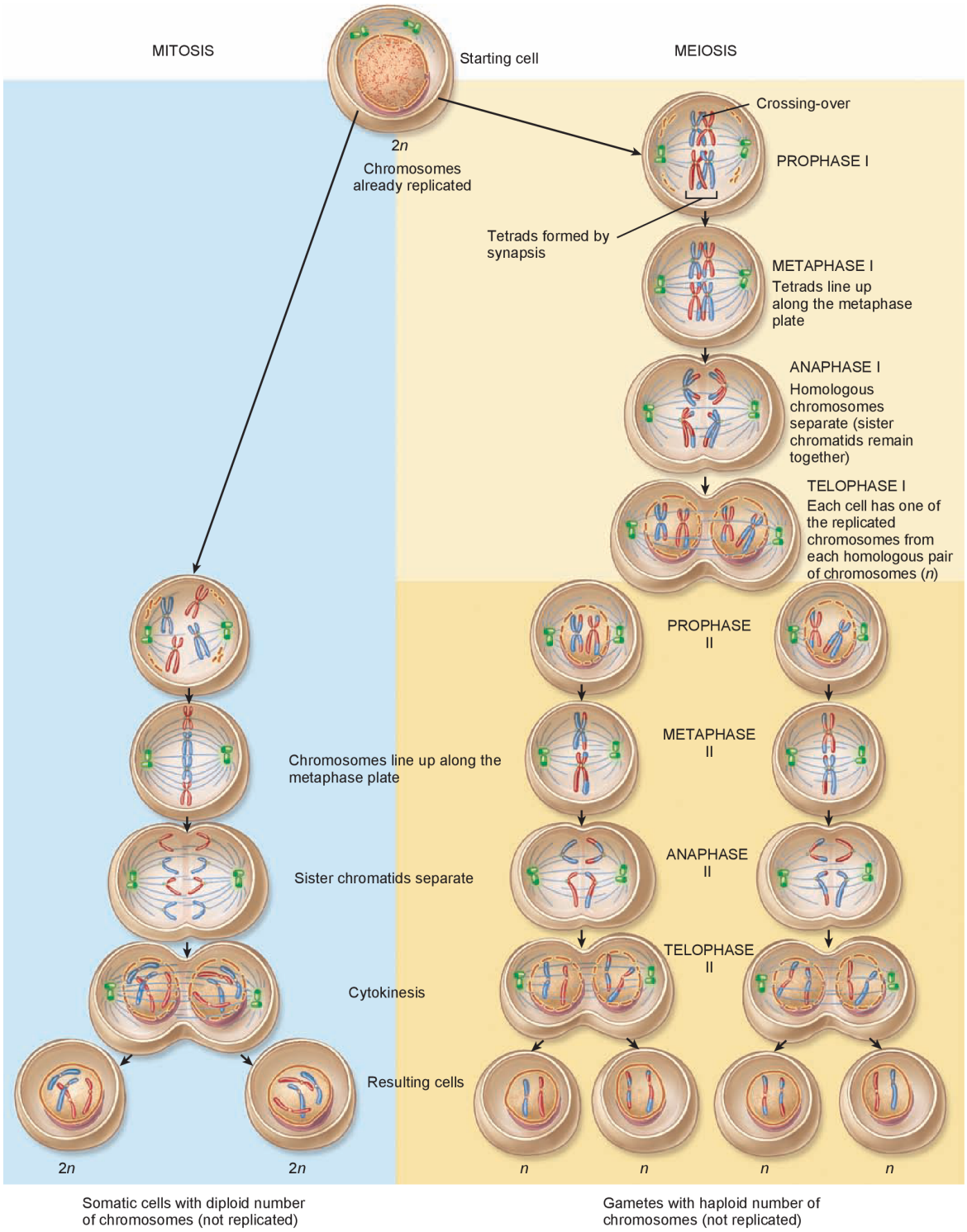

Figure 29: Comparison of the mitosis and meiosis steps. Description of the single steps there meiosis.

5 RM (Robert Mach)

5.1 Molecular biology

1. **What happens during DNA replication, why is it needed?**

   To transmit the genetic information between parents and progeny, the DNA must be replicated. Replication is carried out by a complex group of proteins called helicase that unwind the DNA helix, and (using DNA polymerase and it's associated proteins) to copy or replicate the master template.

2. **Explain the rules of base pairing in DNA?**

Nucleic acid	Purine base		Pyrimidine base	Hydrogen bonds
Deoxyribonucleic acid (DNA)	Adenine	$\longleftrightarrow$	Thymine	2
	Guanine	$\longleftrightarrow$	Cytosine	3
Ribonucleic acid (RNA)	Adenine	$\longleftrightarrow$	Uracil	2
	Guanine	$\longleftrightarrow$	Cytosine	3

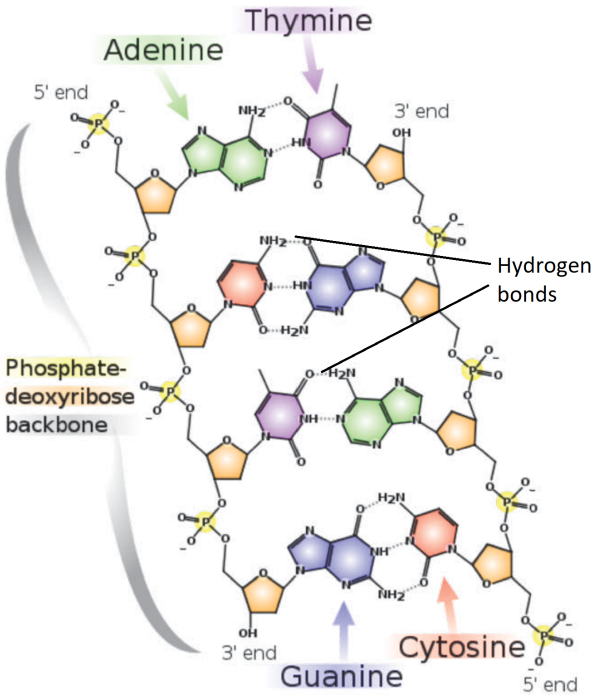

Figure 30: DNA structure.

3. **Base pairing DNA/RNA**

   See answer before.

4. **4 nucleotides building blocks, difference with RNA.**

   The 4 nucleotides building block for DNA are:

a) Adenine
b) Guanine
c) Cytosine
d) Thymine

In RNA the Thymine is replaced by Uracil.

5. **What is a prion, how do prions propagate information?**

   Prions are proteins that propagate themselves by making conformational changes in other molecules of the same type of protein. This change affects the behaviour of the protein. While this represents a transfer of information, prion interactions leave the sequence of the protein unchanged.

6. **Schematic draw the general structure of an amino acid.**

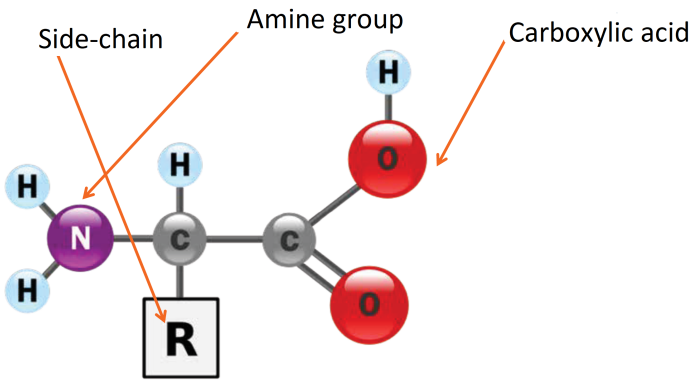

Figure 31: Amino acid structure.

7. **Give five important facts about nucleic acid?**

   a) Are macromolecules composed of chains of monomeric nucleotides.
   b) Form linear polymers of nucleotides which themselves consist of three components, a purine or pyrimidine nucleobase, a pentose sugar and a phosphate group.
   c) In biochemistry these molecules carry genetic information or form structures within cells.
   d) The most common nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).
   e) Nucleic acids are universal in living things, as they are found in all cells and viruses.

8. **Name the five group of amino acids resulting from different side chains.**

   a) Non-polar, alphabetical R chains
   b) Polar, uncharged R groups
   c) Aromatic R groups
   d) Positively charged R groups
   e) Negatively charged R groups

9. **Dogma of molecular biology?**

   Information cannot be transferred back from protein to either protein or nucleic acid. The process of producing proteins is irreversible, a protein cannot be used to create DNA.

10. **Explain the process form DNA to Protein. What are the names of the processes connection the two?**

    This steps shows the building of proteins in eukaryotic cells. In prokaryotic cells, the process of transcription and translation is linked, so the mRNA must not transported out of the nucleus.

    For building a protein out of DNA we must first transcript the DNA to mRNA. Later we can translate the mRNA for building the proteins.

    Transcription is the process by which the information contained in a section of DNA is transferred to a newly assembled piece of messenger RNA (mRNA). It is facilitated by RNA polymerase and transcription factors.

    Translation the mRNA must be transported out of the nucleus into the cytoplasm, where it can be bound by ribosomes. The mRNA is read by the ribosome as triplet codons, usually beginning with an start codon. The three-nucleotide codon in a nucleic acid sequence specifies a single amino acid. Transfer RNA (tRNA) dock on the mRNA one and read one three-nucleotide codon and build out of this information the correct amino acid. Multiple amino acid build one protein.

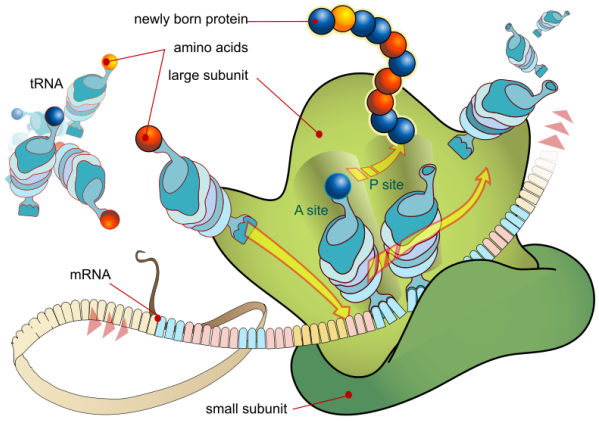

Figure 32: Schematic drawing of the translation of the mRNA.

11. **What happens during reverse transcription. In which special cases can it be found in Nature?**

    Reverse transcription is the special transfer of information from RNA to DNA. It is mediated by the enzyme reverse transcriptase and is caused by retroviruses/ RNA-virus (i.e. HIV) but also occurs in eukaryotes, in the case of retrotransposons and telomere synthesis. Virus kind of hijacks the cell to (re)produce the virus -> RNA of virus is transcribed into DNA and is implemented in the DNA of the cell and in the following, even more of the RNA is produced by the normal transcription mechanism of the cell.

12. What are lipids? Give 4 typical functions.

Lipids form a broad group of naturally occurring molecules. This group includes, among others, fats, waxes, sterols, fat-soluble vitamins and phospholipids.
The main biological functions of lipids include:

a) energy storage

b) structural component of cell membrane

c) signalin molecules

d) Making vitamins (A, D, E and K) available

13. Which flow of information is known in nature?

a) DNA replication (DNA $\longrightarrow$ DNA)

b) Transcription (DNA$\longrightarrow$ mRNA)

c) Translation (mRNA $\longrightarrow$ protein)

d) Reverse Transcription (RNA $\longrightarrow$ DNA)

e) RNA replication (RNA $\longrightarrow$ RNA)

f) conformational changes (prion $\longrightarrow$ prion)

14. What is RNA?

Ribonucleic acid (RNA) is a nucleic acid composed of a chain of many nucleotides (A, G, C, U). Most RNA molecules are single-stranded. n certain types of viruses, RNA is the carrier of genetic information, i.e. the material basis of genes.

15. What are Proteins?

Are biochemical compounds consisting of one or more polypeptides typically folded into a globular or fibrous form, facilitating a biological function.

A polypeptide is a single linear polymer chain of amino acids bonded together by peptide bonds residues.

The sequence of amino acids in a protein is defined by a gene and encoded in the genetic code (see translation). The genetic code specifies 20 "standard" amino acids plus seleno-cysteine and in certain archaea–pyrrolysine.

16. What is the Transcription?

Transcription is the process by which the information contained in a section of DNA is transferred to a newly assembled piece of messenger RNA (mRNA). It is facilitated by RNA polymerase and transcription factors.

17. Explain Translation

Translation is the process where the information on the mRNA (build during transcription) is read out by a ribosome and tRNA and build up a new protein.

18. What is gene coding? How is the information transferred? Fixed gene code?

The genetic code is the way in which the nucleotide sequence of an RNA single strand is translated into the amino acid sequence of the polypeptide chain of a protein. In this context, gene coding is used to identify which amino acid is formed from the three-nucleotide codon.

The information is transmitted by means of a three-nucleotide codon formed from the four nucleotides adenine, guanine, cytosine and thymine/uracil.

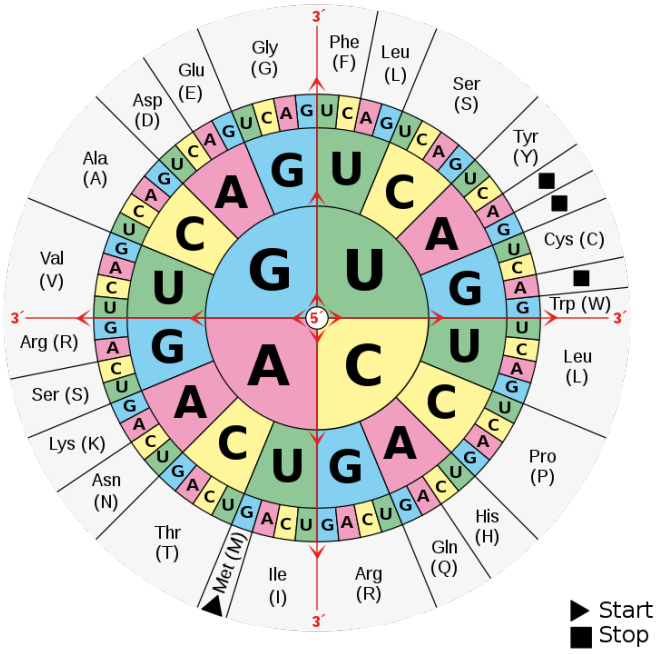

Figure 33: A representation of the genetic code (code sun). In the sequence from the inside to the outside, a base triplet of the mRNA (read from 5' to 3') is here assigned one of the twenty canonical amino acids or a stop codon is marked.

19. Name at lest six different protein functions.

a) Enzymes
b) Immunologically active proteins
c) Proteins used for mobility
d) Transport proteins
e) Membrane proteins
f) Regulatory proteins