DE Bio Unit 4 Study Guide

Compare the parent-offspring relationship in asexual and sexual reproduction

In asexual reproduction, the offspring are identical replicas of the parent. There is no fusion between sperm and egg, so the offspring looks identical to the parent as the chromosomes are completely the same. On the other hand, in sexual reproduction the offspring looks different from the parents. Since there is a fusion between the egg of the mother and the sperm of the father which both have 23 chromosomes, the offspring looks like both his mother and father. The offspring inherits their own combination of the parents genes.

Explain why cell division is essential for prokaryotic and eukaryotic life

Cell division is the continuity of life in both prokaryotes and eukaryotes. In prokaryotic cells, cell division through binary fission allows the organism to expand and increase in population (like yeast). This inadvertently makes life for the organism better. In eukaryotes, cell division allows the organism to grow, replenish dead cells, and create more organisms. In unicellular eukaryotes, cell division creates a whole other duplicate organism. In multicellular eukaryotes, cell division is essential for growth and the replenishment of dead cells.

Explain how daughter prokaryotic chromosomes are separated from each other during binary fission.

Binary fission is the way prokaryotes like bacteria reproduce. First, the chromosomes replicate starting at the origin of replication. This produces two daughter chromosomes which start moving to opposite ends of the cell whilst the cell elongates. Because of the elongation of the cell, the cytoplasm folds inwards causing the cell to split into two which pinches off the two daughter chromosomes.

Compare the structure of prokaryotic and eukaryotic chromosomes.

Prokaryotic chromosomes lack a membrane-enclosed nucleus and other membrane-enclosed cells. The chromosomes are just free-flowing in the cytoplasm. Chromosomes in eukaryotic cells have a membrane-bound nucleus surrounding it. Eukaryotic chromosomes are composed of DNA coiled and condensed around nuclear proteins called histones.

Describe the stages of the cell cycle.

The cell cycle consists of two main stages: the first is interphase and the second is mitosis (+cytokinesis). A cell is primarily in interphase (90% of the cell cycle), and this is the phase where the cell grows and replicates its DNA. Interphase consists of three subphases. The G1 (gap/growth phase one) phase is where the cell grows by creating proteins and organelles to get ready for DNA synthesis. The S (synthesis phase) phase is when the DNA is actually synthesized (the DNA doubles) alongside the centrosomes which are the microtubule organizing centers. Finally, the last subphase of interphase is G2 (gap/growth phase 2) where the cell makes more proteins and organelles to get ready for mitosis.

List the phases of mitosis and describe the events characteristic of each phase.

There are 4 phases of mitosis: prophase+prometaphase, metaphase, anaphase, and telophase.

Prophase + prometaphase: this phase of mitosis is when the nucleus, nucleolus and nuclear envelope start breaking down letting the replicated chromosomes move around, the chromosomes thicken and become visible as sister chromatids, the centrosomes move to opposite poles of the cell, and microtubule spindle fibers are released from the centrosomes and they attach to the centromere of the chromosomes. During prometaphase, the microtubule spindle fibers attached to the kinetochores of the centromere are starting to move them (chromosomes).

Metaphase: In metaphase, the spindle fibers pull the sister chromatids to the metaphase plate/equator/center of the cell. Then, the sister chromatids start getting ready for anaphase. *This phase also has the M checkpoint*

Anaphase: this phase is when the sister chromatids are split at the centromere and travel through the kinetochores to opposite poles of the cell. Now, each chromatid is officially considered a chromosome.

Telophase: this phase is when the new chromosomes reach opposite poles and two new nuclei start forming in opposite ends of the cell. Also, non-kinetochore proteins go to opposite poles elongating the cell to get ready for cytoplasmic division.

Compare cytokinesis in animal and plant cells.

The cytoplasm splits in both plant and animal cells, making two diploid daughter cells. However, the way they do this is different. A cleavage furrow is formed in animal cells, and the cytoplasm pinches away, making the two identical cells. On the other hand, in plant cells, a cell plate is formed which helps break the cell into two since plant cells have a cell wall.

Explain how anchorage, cell density, and chemical growth factors control cell division.

Anchorage dependence, density-dependent inhibition, and growth factors all control cell division since they dictate when/how must the cell divide. Anchorage dependence makes it so the cell must be attached to something (like an ECM of another cell) in order to divide. Density-dependent inhibition makes it so a cell cannot divide if it's in a dense environment (an environment with a lot of cells). Growth factors regulate cell division because proteins are released from one cell which stimulates another cell to divide. For example, PDGF is a growth factor that stimulates the fibroblast cells of humans in a culture to divide.

Explain how cancerous cells are different from healthy cells.

Cancerous cells are not regulated by density-dependent inhibition or anchorage dependence. They do not respond to signals and make their own growth factors. Cancerous cells divide in abnormal, uncontrolled ways; they go against the cell cycle. Therefore, they form genetic mutations that are harmful to humans. A lot of cancer cells can form a malignant tumor which can spread to other regions of the body.

Describe the functions of mitosis.

Mitosis is used for cellular growth and overall organism growth, it helps replenish dead cells, and is the continuity of life for organisms.

Explain how chromosomes are paired.

During the first phase of meiosis, known as prophase one, chromosomes were already replicated. It is good to know that in a human germ cell, there are 46 chromosomes or two sets of 23 chromosomes, each set is given by each parent (so there is a paternal and maternal set). Paternal chromosomes pair up with their corresponding maternal chromosomes which are of similar length, staining pattern, and have the same genes for the same inherited traits. Their chromosomes are called homologous chromosomes or homologs and they form a tetrad.

Distinguish between somatic cells and gametes and between diploid cells and haploid cells.

Somatic cells are cells with all their chromosomes and gametes are cells with half their chromosomes. For example, the human somatic cell consists of 46 chromosomes, whereas a gamete contains 23 chromosomes. A diploid cell has 2 sets of chromosomes, so the diploid number for humans is 46 (somatic cells are diploid). A haploid cell has 1 set of chromosomes, so the haploid number for human gametes is 23.

Explain why sexual reproduction requires meiosis.

It is essential for germ cells to undergo meiosis as it is the basis for sexual reproduction. In sexual reproduction, a process called fertilization transpires where two gametes (one male and one female) fuse to create a zygote which grows into an embryo. Through meiosis, diploid germ cells are converted into haploid gametes, so when the two haploid gametes fuse, a stable diploid cell forms (zygote).

List the phases of meiosis I and meiosis II and describe the events characteristic of each phase.

Prophase 1: chromosomes condense and become visible, homologous chromosomes pair up gene by gene (synapsis) forming a tetrad. Finally, a process called crossing over occurs where

the genes of the homologous chromosomes switch. So the paternal chromosome and maternal chromosomes mix.

Metaphase 1: The homologous chromosomes line up in the metaphase plate by the pulling of the spindle fibers. The microtubule spindle fibers connect to the kinetochores of the chromosome facing their respective poles. Independent assortment occurs here.

Anaphase 1: The homologous chromosomes split up and break apart by the pulling of the spindle apparatus. They start going to opposite poles of the cell. However, the sister chromatids are still intact as are the centromeres.

Telophase 1/Cytokinesis: Once the homologous chromosomes reach each pole, the cytoplasm pinches apart. Two new haploid cells are formed each with 23 chromosomes, but 46 sister chromatids. The sister chromatids are still intact; however, they are unidentical.

Prophase 2: A spindle apparatus is formed (remember this is occurring in two cells simultaneously because there was a division in meiosis 1). The chromosomes with identical sister chromatids start moving to the metaphase plate.

Metaphase 2: The chromosomes finally reach the metaphase plate and the kinetochores get attached to the spindle microtubules. Again, it is crucial to know that the chromatids are identical at this point because of crossing over.

Anaphase 2: The sister chromatids are separated at the centromere by the pulling of the microtubule spindles. They start going to opposite sides of the cell. Now, each chromatid is considered its individual chromosome.

Telophase 2/Cytokinesis: Once the sister chromatids reach opposite ends of the cell, two new nuclei are formed. Then, the cytoplasm splits forming two new cells for each cell. At the end of meiosis, there are 4 haploid, granddaughter cells, each genetically different from each other and the parents.

Compare mitosis and meiosis noting similarities and differences.

Mitosis and meiosis are both processes that occur in certain cells. Mitosis occurs in somatic cells and meiosis occurs in germ, both of which are diploid cells. However, mitosis maintains the number of chromosomes and produces an identical copy of the parent cell. Meiosis reduces the number of chromosomes from 2 sets to 1 set of chromosomes. The daughter cells are differen from the parents and each other. Both undergo DNA synthesis/replication beforehand; however, in mitosis there is only one division after replication whereas in meiosis

there are two divisions. In the first phase of meiosis, meiosis 1, the chromosomes undergo synapsis and cross over. Cohesins cleaved into the chromosomes during metaphase of mitosis; however, cohesion cleaved into the arms of chromosomes during anaphase 1 of meiosis and the centromere during anaphase 2 of meiosis.

Explain how genetic variation is produced in sexually reproducing organisms.

The basis of genetic variation is produced by mutations or changes in the DNA. When there is a mutation, an allele is a form of a gene. Reshuffling of the alleles causes genetic diversity.

The behavior of the chromosomes creates the most genetic diversity during meiosis and fertilization. During prophase 1, homologous chromosomes line up allele by allele and cross over. Crossing over is when there is a break in the DNA of the maternal and paternal homologous, and the break is filled by each other. For example, a break in the maternal chromosome will be filled by the paternal chromosome and vice versa. During metaphase 1, homologous chromosomes undergo independent assortment. Homologs can orient themselves randomly and independently from each other. This creates 8.4 million combinations in human germ cells. Finally, the most genetic variation comes from random fertilization. Any sperm cell can fuse with any ovum, randomly. This probability creates 70 trillion zygote combinations on top of the 8.4 million that occurs during independent assortment. *So, each zygote is genetically different from every other zygote.*

State definitions for gamete, somatic cell, haploid, diploid, crossing-over, genes, alleles, homologous pair/homologous chromosomes.

Gamete: Sex cells that have half as much chromosomes. They are haploid and created via meiosis.

Somatic cells: These are the rest of the human cells (skin, hair, nail, muscle). These cells have 46 chromosomes and are diploid. They undergo mitosis.

Diploid: 2 sets of chromosomes. Human diploid cells have 46 chromosomes. (2n)

Haploid: 1 set of chromosomes. Human haploid cells have 23 chromosomes. (n)

Crossing over: Exchange of genes between homologous chromosomes, resulting in a mixture of parental characteristics in offspring.

Genes: These are units of heredity, made of DNA. Genes code for physical characteristics in us.

Homologous chromosomes: A paternal and maternal pair of chromosomes that are similar in length, staining pattern, and that have the same genes for the same inherited characteristics.

Define and distinguish between these terms: true-breeding, hybrids, the P generation, the F1 generation, and the F2 generation.

True breeding is when the parents produce offspring with the same phenotype as them. This is when the parents are both homozygous for the same traits. Hybrids are produced by the cross of two genetically different parents. Also, hybrids in general are produced when the parents are of different species; for example, the mule. The P generation is the parent generation and it is seen as the first generation. The aforementioned generation's offspring are called the F1 generation. The generation after the F1 is considered the F2 generation (interbreeding of F1), so the P generation is their grandparents.

Define and distinguish between the following pairs of terms: homozygous and heterozygous; dominant allele and recessive allele; genotype and phenotype. Also, define a monohybrid cross and a Punnett square.

Homozygous is when both alleles are the same. The only scenario where recessive alleles are represented is when they are homozygous, so both alleles have to be recessive. Heterozygous when the alleles are different, so one recessive allele and one dominant allele. In heterozygotes, with disregard to the exceptions, only the dominant allele is represented since it masks the recessive allele. Dominant alleles are the alleles that are “stronger”/they can mask the recessive alleles in heterozygotes. Recessive alleles are “weaker” and are only shown as the phenotype when both alleles are recessive. When one does a cross, the letters represent the genotype which is the actual **combination of genes**. Phenotype is the actual appearance/physical representation of the genotype. So the genotype is Aa, which can code for (just as an example) height.

A monohybrid cross is the hybrid of two individuals with homozygous genotypes which result in the opposite phenotype for a certain genetic trait. The cross between two monohybrid traits (TT and tt) is called a Monohybrid Cross.

A punnett square is a mechanism used to predict the genotypic and phenotypic outcome of an offspring.

Name and explain Mendel's laws.

1. Segregation of alleles: during gamete formation, paired alleles separate.
2. Independent Assortment: genes on the same chromosomes sort themselves independently of each other during meiosis.
3. Principle of dominance: If a dominant allele is present, it will be expressed.

Describe the structure of homologous chromosomes.

Homologous chromosomes are pairs of chromosomes that are the same length, have the same staining pattern, and carry genes for the same traits at corresponding loci. One is inherited from the father (paternal) and the other from the mother (maternal). Each homologous chromosome consists of two sister chromatids held together by a centromere. When homologous chromosomes pair up during meiosis, they form a structure called a tetrad, which consists of four chromatids.

Explain how family pedigrees can help determine the inheritance of many human traits.

Shows the inheritance of a trait in a family through multiple generations, demonstrates dominant or recessive inheritance, and can also be used to deduce genotypes of family members.

Explain how recessive and dominant disorders are inherited. (be able to use a Punnett square)

Well, in general the inheritance of disorders are all up by chance. However, it is more likely that the offspring will inherit dominant disorder rather than recessive disorders. If both parents have the recessive disorder, the offspring will have the disorder. If one parent has the recessive disorder, and the other parent is homozygous dominant, the offspring cannot have the disorder. If one parent has the recessive disorder, and the other parent is a carrier, the offspring has a 50% chance to inherit the disorder. If both parents are carriers, the offspring has a 25% chance of inheriting the disorder. Dominant disorders are more commonly inherited as a carrier will have the disorder. If both parents are homozygous dominant for a dominant disorder or one

parent is homozygous dominant and the other is heterozygous or homozygous recessive, there is a 100% chance of the offspring having the disorder. If both parents are heterozygous, there is a 75% chance the offspring has the disorder. Only if both parents are homozygous recessive for a dominant disorder, there is no chance the offspring will have it.

Describe the types and use of fetal testing: amniocentesis, chorionic villus sampling, and ultrasound imaging.

Amniocentesis: During pregnancy, amniotic fluid can be drawn from the pregnant mother; the fluid probably contains fetal cells. Those cells can then be biochemically tested or karyotyped to see if there are any deformities.

Chorionic Villus Sampling: Chorionic villus sampling is when chorionic villus tissue is drawn from the placenta. Like amniocentesis, the tissue will contain fetal cells to be analyzed.

Ultrasound imaging: While blood can be drawn from the mother 15-20 weeks in pregnancy to analyze fetuses at risk of birth defects, ultrasound imaging is a safer way to analyze and visualize the fetus.

Describe the inheritance patterns of incomplete dominance, multiple alleles, codominance, pleiotropy, and polygenic inheritance. Be able to cross involving incomplete dominance and ABO blood group.

Incomplete dominance: In nature there are many different dominant genes for a certain phenotype. For example, in flowers, the dominant colors include white and red. If a homozygous white flower crossed with a homozygous red flower. The phenotype would be a blend of two (incomplete dominance) and would show pink. Instead of one dominant allele masking the other, the two dominant alleles mix and dilute each other. Also in incomplete dominance, if one is heterozygous they may have a “middle” version of the trait. For example individuals who are heterozygous for hemocholestroglycemia have a mid level of it.

Multiple alleles: A monohybrid cross is done with one allele like hair length. In some cases, there are multiple alleles that come together, linked-genes. These genes will come together, so a dihybrid cross has to be done since there are two genes all in one. For example hair color and hair length can all come together in a long genotype.

Codominance: Dissimilar to incomplete dominance where the two dominant alleles blend together, in codominance, the alleles are represented and shown equally.

Pleiotropy: Pleiotropy is when one gene affects a plethora of other traits. For example, sickle cell disease is a recessive genetic disorder. Someone with sickle cell disease will produce an altered type of hemoglobin and will have sickles-shaped red blood cells. However, it also damages organs and causes anemia. The sickle cell allele and the non sickle cell allele are codominant, and a carrier for sickle cell disease is resistant to malaria. As one can observe, this one sickle cell gene is affecting many things.

Polygenic Inheritance: Polygenic inheritance is when many different genes affect one phenotypic characteristic. For example skin color is affected by many different alleles, not just two.

Define the chromosome theory of inheritance. Explain the chromosomal basis of the laws of segregation and independent assortment.

This theory states that individual genes are found at specific locations on particular chromosomes and that the behavior of chromosomes during meiosis can explain why genes are inherited according to Mendel's laws

The members of a homologous pair separate in meiosis, so each sperm or egg receives just one member. This process mirrors segregation of alleles into gametes in Mendel's law of segregation.

The members of different chromosome pairs are sorted into gametes independently of one another in meiosis, just like the alleles of different genes in Mendel's law of independent assortment.

Define the term: linked genes.

Linked genes are genes that are closely packed on the chromosome, they are very close to each other. In consequence, linked genes tend to be inherited together.

Explain how sex is genetically determined in humans and the significance of the SRY gene.

Of the 46 chromosomes in a human somatic cell, 2 of them are sex chromosomes. Sex chromosomes can either be X or Y. Individuals with XX chromosomes are female, whereas individuals with XY chromosomes are male. The SRY gene is in males and it encodes for testes development. The lack of this gene allows the development of the ovaries.

Describe patterns of sex-linked inheritance and examples of sex-linked disorders. Be able to do Punnett Square.

Sex-linked inheritance is on mainly on the X chromosome, so the different sex-linked disorders and diseases are considered “x-linked” as they are only related to the X chromosome. Most sex-linked diseases and disorders are recessive and more prevalent in males. Males only have one allele whereas females have two alleles like normal; the reason for this is that males have a Y chromosome which does not really have genes besides the SRY gene, and females have two XX’s. Women can be carriers of different sex-linked disorders, whereas males have it or not. The sex-linked diseases and disorders male offspring inherit are from the Mom since the dad only determines the sex for males.

Some sex-linked disorders/diseases are muslce dystrophy which is progressive muscle wasting, hemophilis which is the inability to blood clot, and red-green color blindness.