**CELLS STUDY GUIDE**

**Design a scientific investigation with appropriate methods of control to test a hypothesis (including independent and dependent variables), and evaluate the designs of sample investigations.**

* Design a controlled scientific investigation in which one variable at a time is deliberately changed and the effect on another variable is observed while holding all other variables constant.

The steps in designing an investigation include:

* Stating the purpose in the form of a testable question or problem statement
* Researching information related to the investigation
* Stating the hypothesis
* Describing the experimental process
	+ Planning for independent and dependent variables with repeated trials
	+ Planning for factors that should be held constant (controlled variables)
	+ Setting up the sequence of steps to be followed
	+ Listing materials
	+ Planning for recording, organizing and analyzing data
* Understand that the statement that predicts the relationship between an independent and dependent variable is called a *hypothesis*.
* Understand that the *independent variable* is the variable that the experimenter deliberately changes or manipulates in an investigation.
* Understand that the *dependent variable* is the variable that changes in an investigation in response to changes in the independent variable.
* Understand that the independent variable is the “cause” and the dependent variable is the “effect” in the “cause-effect” relationship that is predicted.
* Understand that all the other possible variables in the investigation should be held constant so that only one variable (the independent) is tested at a time. The variables which are held constant are called *controlled variables*.
* Understand that the investigator should conduct repeated trials to limit random error in measurements.
* Understand that, when appropriate, a *control group* is set up as a basis of comparison to test whether the effects on the dependent variable came from the independent variable or from some other source.
* Evaluate the design of an experiment by assessing whether the steps of the investigation are presented.

**Organize and interpret the data from a controlled scientific investigation by using mathematics (including formulas and dimensional analysis), graphs, models, and/or technology.**

* Organize data which is collected from a controlled scientific investigation.
* Data should be organized in charts which list the values for the independent variable in the first column and list the values for the dependent variable in a column to the right of the independent variable.
* Use graphs to organize data from controlled investigations.
* Data should be recorded on a graph with the independent variable plotted on the “X” axis and the dependent variable plotted on the “Y” axis. (DRY MIX)
* Choose scales for both the horizontal axis and the vertical axis.
* There should be two data points more than is needed on the vertical axis.
* The horizontal axis should be long enough for all of the data points to fit.
* The intervals on each axis should be marked in equal increments.
* Label each axis with the name of the variable and the unit of measure.
* Title the graph.
* Use the graphs to analyze and interpret data to determine a relationship between the dependent and independent variables.
* A line graph is used for continuous quantitative data.
* A bar graph is used for non-continuous data which is usually categorical.
* A circle graph shows a relationship among parts of a whole. Circle graphs often involve percentage data.

**Use appropriate safety procedures when conducting investigations.**

* Practice the safety procedures stated in every scientific investigation and technological design problem conducted in the laboratory and classroom. Follow safety procedures regarding
	+ Personal safety – follow only the designated lab procedures; be sure to understand the meaning of any safety symbols shown, wear proper clothing and shoes for the lab, use protective equipment (goggles,

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aprons,…), tie back loose hair, never eat or drink in lab room, use proper technique for touching or smelling materials, be careful when using sharps (any item that can puncture, cut, or scrape the skin.)

* + Work area safety – use only designated chemicals or equipment, keep work area clear and uncluttered, do not point heated containers at yourself or anyone else, be sure all burners or hot plates are turned off when the lab is finished, know the location and use of the fire extinguisher, safety blanket, eyewash station, safety shower, and first aid kit, disconnect electrical devices, follow clean-up procedures as designated by the teacher.
* Safely and accurately practice appropriate techniques associated with the equipment and materials used in the activities conducted in the laboratory and classroom.
* Abide by the safety rules in the course safety contract.

**Proficiently use proper light microscopic techniques as well as determine total power magnification.**

* Identify the parts of a light microscope.
* Know steps to using a light microscope.
* Know steps to make a wet mount (temporary slide).
* Determine total magnification. (ocular lens x eyepiece lens)
* Understand that scanning and electron microscopes reveal greater detail of cells and have much greater total magnification powers than a light microscope.

**Summarize the structures and functions of organelles found in a eukaryotic cell (including the nucleus, mitochondria, chloroplasts, lysosomes, vacuoles, ribosomes, endoplasmic reticulum [ER], Golgi apparatus, cilia, flagella, cell membrane, nuclear membrane, cell wall, and cytoplasm).**

An *organelle* is a cell structure that performs a specialized function within a eukaryotic cell. Organelles found in a eukaryotic cell include:

* *Nucleus* contains the chromosomes which are composed of DNA (a chemical compound called deoxyribonucleic acid); functions in the genetic control of the cell.
* *Mitochondria* are the sites of cellular respiration, a process which supplies the cell with energy.
* *Chloroplasts* are found only in plant cells, contain the green pigment, *chlorophyll,* which absorbs energy from the Sun to convert carbon dioxide and water into sugar through the process of photosynthesis.
* *Lysosomes* contain chemicals called *enzymes* necessary for digesting certain materials in the cell.
* *Vacuoles* store materials such as water, salts, proteins, and carbohydrates; vacuoles in animal cells (if they are present) are much smaller than those in plant cells. Some unicellular organisms that live in hypertonic environments have a *contractile vacuole* that can pump water out to prevent bursting.
* *Ribosomes* are the sites of protein synthesis; some are located on the ER, others are found in the cytoplasm.
* *Endoplasmic reticulum (ER)* is a complex, extensive network that transports materials throughout the inside of a cell.
	+ Rough ER has ribosomes attached to the surface is ribosome-studded.
	+ Smooth ER has no attached ribosomes.
* *Golgi apparatus* modifies, collects, packages, and distributes molecules within the cell or outside the cell.
* *Cilia* are short hair-like projections responsible for the movement of animal cells or protists.
* *Flagella* are long whip-like projections responsible for the movement of some animal cells, bacteria, or protists.
* *Cell membrane* (sometimes called the plasma membrane) is the cell structure that encloses the cell and regulates the passage of materials between the cell and its environment; the cell membrane also aids in protection and support of the cell.
* *Cell wall* is the cell structure that surrounds the cell membrane for protection and support in plant cells, bacteria, fungi, and some protists, and allows for specific substances to pass in and out of the cell.
* *Cytoplasm* is the semi-fluid material inside the cell containing molecules and the organelles, exclusive of the nucleus; is bound by the cell membrane.

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**Locate** and **identify** each of the above organelles when presented with a scientific drawing, diagram, or model of a eukaryotic cell. For example:



**Compare the structures and organelles of prokaryotic and eukaryotic cells.**

The major difference between prokaryotic cells and eukaryotic cells is the presence of a nucleus.

* *Prokaryotic cells* do not have a nucleus; the DNA in prokaryotic cells is not separated from the rest of the cell by a nuclear membrane (envelope). Most prokaryotes have one circular chromosome called a plasmid.
* In *eukaryotic cells*, the DNA is organized into linear chromosomes and the chromosomes are separated from the cytoplasm by a nuclear membrane.

Prokaryotic cells differ from eukaryotic cells in other ways:

* Prokaryotic cells lack most of the other organelles which are present in the cytoplasm of eukaryotic cells. (No membrane bound organelles.)
* Prokaryotes are smaller and less complex than eukaryotes.
* Prokaryotic cells, however, do contain ribosomes, the site of protein synthesis.

 Most prokaryotes are unicellular organisms, such as bacteria.

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**Explain the process of cell differentiation from stem cells.**

* In the development of most multicellular organisms, a single cell (fertilized egg) gives rise to many different types of cells, each with a different structure and corresponding function.
	+ The fertilized egg gives rise to a large number of cells through *cell division*, but the process of cell division alone could only lead to increasing numbers of identical cells.
	+ As cell division proceeds, the cells not only increase in number but also undergo *differentiation* becoming specialized in structure and function.
	+ The various types of cells (such as blood, muscle, or epithelial cells) arrange into tissues which are organized into organs, and, ultimately, into organ systems.
* Nearly all of the cells of a multicellular organism have exactly the same chromosomes and DNA.
	+ During the process of differentiation, only specific parts of the DNA are activated; the parts of the DNA that are activated determine the function and specialized structure of a cell.
	+ Because all cells contain the same DNA, all cells initially have the potential to become any type of cell.

* *Stem cells* are unspecialized cells that continually reproduce themselves and have, under appropriate conditions, the ability to differentiate into one or more types of specialized cells.
	+ Embryonic cells, which have not yet differentiated into various cell types, are called embryonic stem cells.

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* + Stem cells found in adult organisms, for instance in bone marrow, are called adult stem cells.
	+ Scientists have recently demonstrated that stem cells, both embryonic and adult, with the right laboratory culture conditions, differentiate into specialized cells.

**Explain how active, passive, and facilitated transport serve to maintain the homeostasis of the cell.**

*Homeostasis* refers to the necessity of an organism to maintain constant or stable conditions. In order to maintain homeostasis, all organisms have processes and structures which respond to stimuli in ways that keep conditions in their bodies conducive for life. Homeostasis depends in part on appropriate movement of materials across the cell membrane.

* Materials needed for cellular processes must pass into cells so they can be utilized. For example, oxygen and glucose are continuously needed for the process of cellular respiration.
* Waste materials from cellular processes must pass out of cells as they are produced. For example, carbon dioxide is continuously produced within the cell during the process of cellular respiration.
* The cell membrane regulates the passage of material into and out of the cell. Depending on the needs of the cell, excess substances must move out of the cell and needed substances must move into the cell.
* Each individual cell exists in a fluid environment, and the cytoplasm within the cell also has a fluid environment. The presence of a liquid makes it possible for substances (such as nutrients, oxygen, and waste products) to move into and out of the cell.
* A cell membrane is *semipermeable (selectively permeable)*, meaning that somesubstances can pass directly through the cell membrane while other substances cannot.

Materials can enter or exit through the cell membrane by passive transport or active transport. *Passive transport* is a process by which substances move across a cell membrane but do not require energy from the cell. Types of passive transport are diffusion, osmosis, and facilitated diffusion.

* *Diffusion* is the spreading out of molecules across a cell membrane until they are equally concentrated. It results from the random motion of molecules and occurs along a *concentration* *gradient* (molecules move from an area of higher concentration to an area of lower concentration); substances that are able to pass directly across the cell membrane can diffuse either into a cell or out of a cell.

**Diffusion across a semipermeable membrane**



**Semipermeable Membrane**

**Semipermeable Membrane**

* *Osmosis* is the diffusion of water molecules through a selectively permeable membrane from an area of greater concentration of water to an area of lesser concentration of water.
	+ If two solutions with the same solute concentration are separated by a selectively permeable membrane, water molecules will pass through the membrane in both directions at the same rate so the concentration of the solutions will remain constant.
	+ The diffusion of water molecules is a passive transport process because it does not require the cell to expend energy.

If cells are placed in solutions that are different in concentration from that of the cell, the cells may be damaged and even shrivel or burst (*lyse*).

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Water concentration greater outside the cell than inside so water moves into the cell

Water concentration the same inside and outside the cell so there is no net movement of water

Water concentration greater inside the cell than outside so water moves out of the cell



* *Facilitated diffusion (transport)* is the process by which some substances that are not able to pass directly through a cell membrane are able to enter the cell with the aid of *transport proteins*. Facilitated diffusion occurs along a concentration gradient and does not require energy from the cell.
	+ Some substances have chemical structures that prevent them from passing directly through a cell membrane. The cell membrane is not permeable to these substances.
	+ Transport proteins provide access across the cell membrane.
	+ Glucose is an example of a substance that passes through the cellular membrane using facilitated diffusion.



Facilitated Diffusion

*Active transport* is another one way that substances can move through a cell membrane. However, molecules move against the concentration gradient (from an area of low concentration to an area of high concentration) and require the cell to expend energy.

* One process of active transport happens when cells pump molecules through the cell membrane.
	+ Unlike the process of facilitated diffusion, in active transport, molecules are “pumped” across the cell membrane by transport proteins. This pumping process requires an expenditure of chemical energy.
	+ Because this process does not depend on diffusion, cells can use this process to concentrate molecules within the cell, or to remove waste from a cell.
* Another process of active transport happens when molecules are too large to pass through a cell membrane. These molecules require the use of *vesicles* (small vacuoles) to help them through the membrane.
	+ If the large molecule is passing into the cell, the process is called *endocytosis*.
	+ If the large molecule is passing out of the cell, the process is called *exocytosis.*

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**Summarize the characteristics of the cell cycle: interphase (G1, S, G2); the phases of mitosis (prophase,**

**metaphase, anaphase, and telophase); and plant and animal cytokinesis.**

The *cell cycle* is a repeated pattern of growth and division that occurs in eukaryotic cells. This cycle consists of three phases. The first phase represents cell growth while the last two phases represent nuclear and cell division.

***Interphase***

* Cells spend the majority of their cell cycle in interphase. The purpose of interphase is for cell growth. By the end of interphase a cell has two full sets of DNA (chromosomes) and is large enough to begin the division process.
* Interphase is divided into three phases. Each phase is characterized by specific processes involving different structures.
	+ During the *G1 (gap 1) phase*, the cell grows and synthesizes proteins.
	+ During the *S (synthesis) phase*, chromosomes replicate and divide to form identical sister *chromatids* held together by a *centromere.*
	+ During the *G2 (gap 2) phase*, cells continue to grow and produce the proteins necessary for cell division.

Chromosome composed of two sister chromatids



***Mitosis***

* The purpose of mitosis is cell division: making two cells out of one. Each cell has to have its own cytoplasm and DNA. The DNA that replicated in Interphase when two chromosome strands became four strands (two strands per chromatid). In mitosis the four strands (two sister chromatids) have to break apart so that each new cell only has one double-stranded chromosome.
* Mitosis, which follows Interphase, is divided into four phases. Each phase is characterized by specific processes involving different structures.
	+ *Prophase* is characterized by four events:
		- Chromosomes condense and are more visible.
		- The nuclear membrane (envelope) disappears.
		- By the end of prophase the centrioles (cell organelles that produce spindle fibers) have separated and taken positions on the opposite poles of the cell.
		- Spindle fibers form and radiate toward the center of the cell.
	+ *Metaphase*(the shortest phase of mitosis) is characterized by two events:
		- Chromosomes line up across the middle of the cell.
		- Spindle fibers connect the centromere of each sister chromatid to the poles of the cell.
	+ *Anaphase* is characterized by three events:
		- Centromeres that join the sister chromatids split.
		- Sister chromatids separate becoming individual chromosomes.
		- Separated chromatids move to opposite poles of the cell.
	+ *Telophase* (the last phase of mitosis) consists of four events:
		- Chromosomes (each consisting of a single chromatid) uncoil.
		- A nuclear envelope forms around the chromosomes at each pole of the cell.
		- Spindle fibers break down and dissolve.
		- Cytokinesis begins. (There is an overlap between telophase and cytokinesis.)

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***Cytokinesis***

*Cytokinesis* is the division of the cytoplasm into two individual cells. The process of cytokinesis differs somewhat in plant and animal cells.

* In animal cells the cell membrane forms a *cleavage furrow* that eventually pinches the cell into two nearly equal parts, each part containing its own nucleus and cytoplasmic organelles.
* In plant cells a structure known as a *cell plate* forms midway between the divided nuclei, which gradually develops into a separating membrane. The cell wall forms in the cell plate.

 

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Animal Cell Telophase/CytokinesisPlant Cell Telophase/Cytokinesis

**Summarize how cell regulation controls and coordinates cell growth and division and allows cells to respond to the environment, and recognize the consequences of uncontrolled cell division.**

The cell cycle is driven by a *chemical control system* that both triggers and coordinates key events in the cell cycle. The cell cycle control system is regulated at certain checkpoints.

* Signals from inside the cell (internal signals) and from outside the cell (external signals) are involved in turning the process of cell division off and on.
	+ An *internal signal* involves the cell sensing the presence of chemicals, called enzymes, which are produced inside the cell
	+ An *external signal* involves the cell sensing the presence of a chemical (such as a growth factor) which was produced in other specialized cells.
* Cells can also respond to physical signals from their environment.
	+ Cells sense when they are too closely packed and cell division is turned off.
	+ Cells sense when they are not in contact with a surface and cell division is turned on.
* A *checkpoint* in the cell cycle is a critical control point where stop and go signals can regulate the cycle. The cell division mechanism in most animal cells is in the “off” position when there is no stimulus present. Specific stimuli are required to start the processes.

Sometimes cells do not respond normally to the body’s control mechanisms and divide excessively.

* *Cancer cells* are an example of cells that do not heed the normal signals which shut down the cell division process; they continue to divide even when they are very densely packed and/or there is no growth factor present.
	+ Cancer begins when a single cell is transformed into a cancer cell, one that does not heed the regulation mechanism Normally the body’s immune system will recognize that the cell is damaged and destroy it, but if it evades destruction, it will continue to divide and each daughter cell will be a cancer cell.
	+ A mass of these cells that invades and impairs the functions of one or more organs is called a *malignant tumor*.
	+ A *benign tumor* is a mass of abnormal cells that remains at the original site.
* Cancer cells may also separate from the original tumor, enter the blood and lymph vessels of the circulatory system, and invade other parts of the body, where they grow to form new tumors.

 **RFM**