Name ______________________________ Date __________
AP Biology Mr. Collea

Diffusion and Osmosis

<u>Background Information</u>:

Many aspects of the life of a cell depend on the fact that atoms and molecules are constantly in motion (*the concept of kinetic energy*). This kinetic energy results in molecules bumping into and rebounding off each other and moving in new directions. One result of this molecular motion is the process of diffusion.

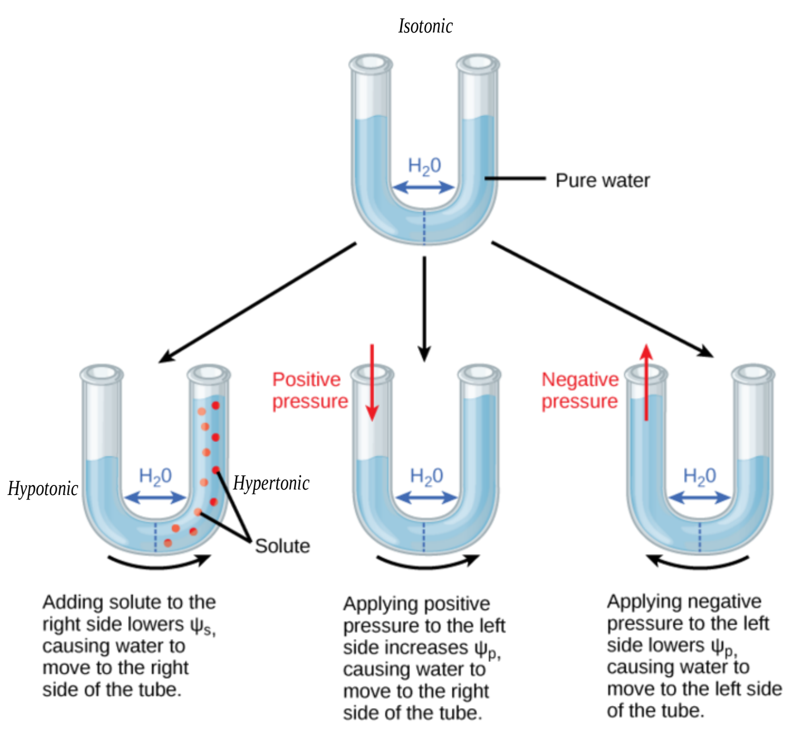
Diffusion is the random movement of molecules from an area of higher concentration to an area of lower concentration. **Osmosis** is a special case of diffusion. It is the diffusion of water through a selectively permeable membrane from a region of higher water potential to a region of lower water potential until equilibrium is reached. Water potential is the measure of free energy of water in a solution.

Water potential is the free energy of water, water will always move from an area of higher water potential to an area of lower water potential (*high free energy to low free energy*). Water potential has 2 components: **pressure potential (Ψ_p)** - which results from the exertion of pressure either positive or negative on a solution <u>AND</u> **solute potential (Ψ_s)** - which is dependent on solute concentration. These terms can be reviewed on pages **751-752** in your textbook.

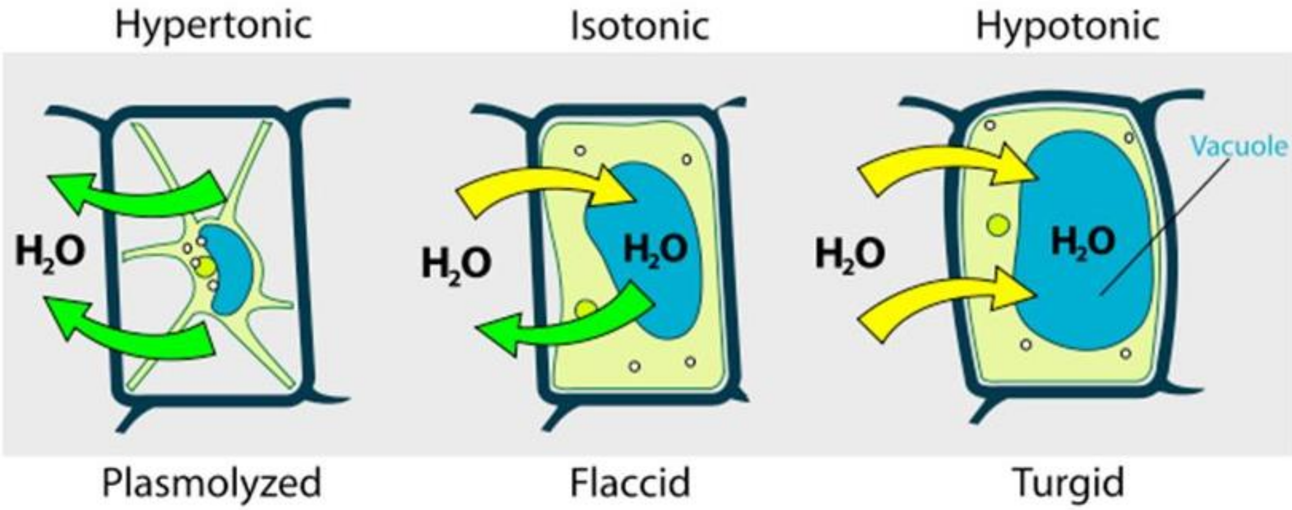
Water Potential = Pressure Potential + Solute Potential

$$\Psi = \Psi_p + \Psi_s$$

The water potential of pure water in a beaker at STP is 0 because both solute and pressure potentials are 0. The addition of a solute to water lowers the water potential (*to a negative value*). When dealing with plant cells like those found in a potato or a red onion, water potential inside a cell increases as a result of more solute dissolved in the fluids outside the cell. When placed in a pure water situation, the cells are now **hypertonic** to the environment. The water potential outside the cell is now higher than inside the cell. Water will diffuse into the cell until the pressure potential equalizes. As a result, the cell will swell. Conversely, if solute is added to the water of the beaker so that the water potential is higher in the cell than the beaker, the cell is said to be **hypotonic** to its surroundings and water will diffuse out of the cell until the pressures are equal. As a result, the cell will shrink (*plasmolysis*). Water basically moves from an area of high water potential to a low water potential.



How can we predict which way the water will move?



- Water will always move TOWARDS the higher solute concentration.
- Water will always move from an area of HIGH water potential to an area of LOW water potential.

Hypotonic → Hypertonic

Activity Overview:

In Part I of this lab, you will work with a cell model using dialysis tubing to represent your cell. You will fill dialysis tubing with 0.5M sucrose solution and immerse it in known concentrations of sucrose solutions, calculate and graph the % change in mass in each dialysis tube and explain the changes in the tubes in terms of water potential. In Part II of this lab, you will be working with a real cell system - potato cells. You will immerse cores of potato in different (*unknown*) molar concentrations of sucrose to determine the solute potential of potato cells. Part III is a review of the Plasmolysis Lab from Honors Biology in which we will surround red onion cells first with distilled water and then with a 15% salt solution and observe them under a compound light microscope and explain the changes in the plant cells in terms of water potential.

Methods:

Materials:

Part I. Potato Cores
Small Petri Dish
3 Potato Cores
Sucrose Solution
Paper Towels
Forceps
Digital Scale

Part III. Plasmolysis
Glass Slide / Cover slip
Red Onion Specimen
15% NaCl solution
Paper Towels
Microscope

Part I: Solute Potential of Potato Cells

Part I: Procedure

__1. Using a cork borer, Mr. Collea will provide you with 3 potato cylinders for each Petri dish.

__2. CAREFULLY blot the potato cylinders on a paper towel to dry using the forceps to **ALWAYS** handle the specimens. Be sure to be **consistent in your potato cylinder drying methods**.

__3. Place the potato cylinders immediately into the small Petri dish and cover to avoid evaporation.

__4. Quickly determine the total mass of all potato cylinders together using the digital scale and record data in **Table 2**. *Remember to always use forceps in handling your specimens and to* ***IMMEDIATELY*** *place the covers back on the Petri dish when finished to prevent evaporation.*

__5. After you have massed all of your potato core specimens, place them in their designated location in the biology lab where they will be submerged in an unknown sucrose solution and left to stand overnight.

__6. The next day, CAREFULLY carry your Petri dishes back to your lab table, CAREFULLY remove the potato cores from one of the solution using forceps, blot and dry them gently on paper towel **using the same method from yesterday** and determine their combined mass. Do the same for your other two Petri dishes and record your data on **Table 2**.

__7. Calculate the percent change in mass for each and record results in **Table 2**.

__8. Graph the class data for the percent change in mass on **Graph 2.**

Data and Results:

Table 1. Potato Core Results: Individual Data

Petri Dish	Initial Mass (g)	Final Mass (g)	Mass Difference	% Change in Mass*
A				
B				
C				
D				
E				
F				

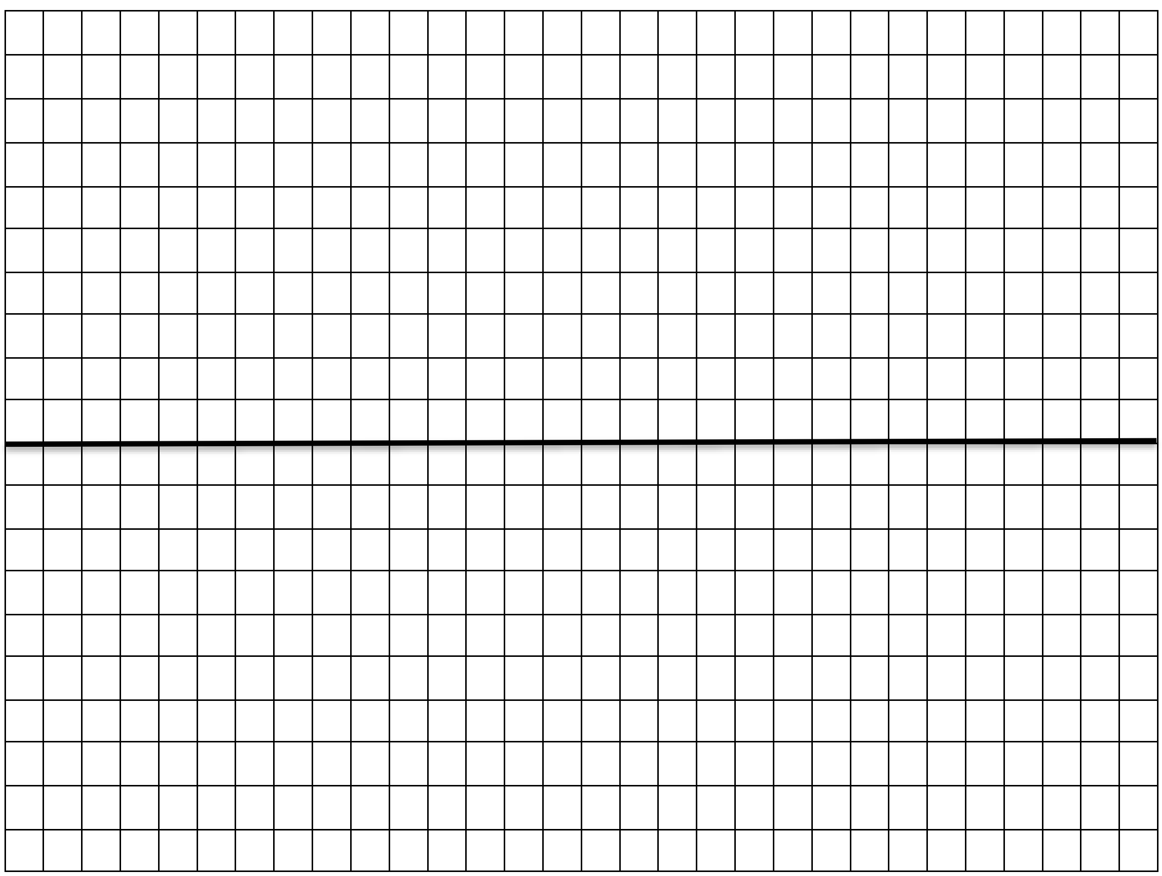
$$\text{*Percent Change in Mass} = \frac{\text{(Final Mass)} - \text{(Initial Mass)}}{\text{Initial Mass}} \times 100$$

Table 2. Percent Change in Mass of Potato Core: Class Data

	A	**B**	**C**	**D**	**E**	**F**
Group 1						
Group 2						
Group 3						
Group 4						
Group 5						
Group 6						
Group 7						
Group 8						
Avg.						
	A	**B**	**C**	**D**	**E**	**F**
Molarity						

Graph 1. Percent Change in Mass of Potato Cores at Different Molarities of Sucrose

Percent Change in Mass



Molar Concentration of the Potato Cores = ____________ *M*

Part II. Plasmolysis in Red Onions

Structures you should see and label include: cell wall, cell membrane, cytoplasm, vacuole

Red Onion Cells in Distilled Water

Red Onion Cells in 15% Salt Solution

Part III. Active Transport in Yeast

Active transport is a process used by living organisms to cause molecules to move into or out of an area *against* the concentration gradient. When a cell is <u>alive</u> the cell membrane can use active transport mechanisms to make sure the appropriate molecules are allowed to build up inside the cell and the appropriate molecules are kept out of the cell regardless of their concentrations.

Control:
Living Yeast without Dye

Living Yeast with Dye

Boiled Yeast with Dye

<u>Percentage of Cells with Dye Inside of Them</u>

Post-Lab Questions:

Using the formula below, calculate the solute potential and water potential for each of the lab set ups.
*Remember **ESA**!*

Water Potential: $\Psi = \Psi_P + \Psi_S$
Solute Potential : $\psi s = -iCRT$

i = Ionization constant
C = Molar concentration
R = Pressure Constant (R = 0.0831 liter bars/mole ºK)
T = Temperature (ºK) (273 + ºC of solution)

1. Calculate the solute potential **and** water potential of a 0.0 M sugar solution at 22 ºC.

2. Calculate the solute potential **and** water potential of a 0.2 M sugar solution at 22 ºC.

3. Calculate the solute potential **and** water potential of a 0.6 M sugar solution at 22 ºC.

4. Calculate the solute potential **and** water potential of a 0.8 M sugar solution at 22 ºC.

5. What are the functions of the cell membrane?

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6. The cell membrane is often described as a bilayer. Explain this term. What two layers make up the cell membrane?

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7. Where are proteins found in the cell membrane?

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8. Explain why the cell membrane is described as a Fluid Mosaic Model.

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9. Give an example of a molecule that is unable to pass through the cell membrane.
Explain why.

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10. Explain the function of a transport protein and give an example of how a transport protein is used in a specific cell in the body.

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11. Explain the similarities and difference between active transport and facilitated diffusion and give an example of each.

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12. Some of the proteins on the surface of the cell are known as receptor proteins because they receive *messages* from outside the cell. Draw a diagram to show a receptor protein and the signal molecule it receives. (*Remember the importance of shape in biology*.)

13. What is one possible message that one cell might send to another cell?

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14. What is the function of cholesterol in the cell membrane?

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15. Summarize, in terms of water potential, the process of osmosis.

16. What is plasmolysis?

17. Explain the changes observed in the red onion cells using the terms, *water potential*, *hypertonic* and *hypotonic*.

18. In the winter, icy roads are often salted to remove the ice and make them less slippery. Grasses and other herbaceous plants often die near the side of these roads. What causes this to happen?

19. When a person is given fluid intravenously (an I.V.) in the hospital, the fluid is typically a saline solution isotonic to human body tissues. Explain why this is necessary.

20. What if the unthinkable happened at the hospital! A patient was given an I.V. bag with distilled water in it rather than saline solution. Describe what would happen to their red blood cells and explain why this would occur.

21. Many freshwater one-celled organisms, like Paramecium, have contractile vacuoles. These structures collect and pump out excess water that accumulates in the cell. Explain, in terms of water potential, why these organisms needs such a structure.

22. Popcorn sold at movie theaters is very salty, causing people to become thirsty and to buy soft drinks...cha ching. Explain why salty popcorn causes this thirst.

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23. Explain why soft-bodied invertebrates, like slugs, die when you pour salt on them.

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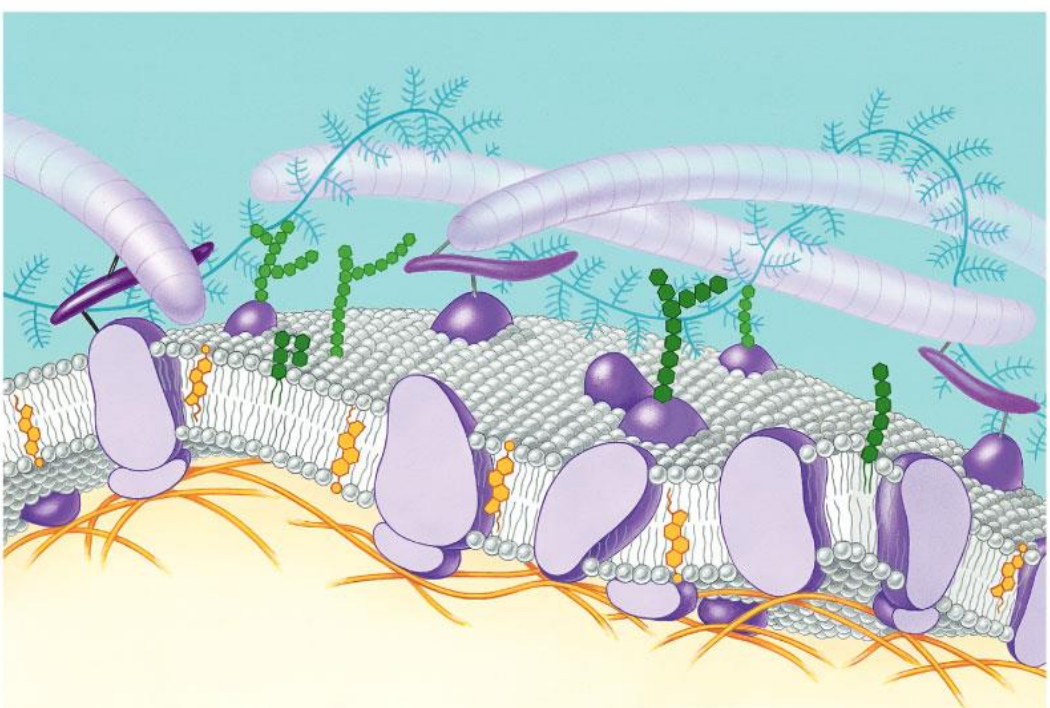
24. Label the diagram of the plasma membrane below.

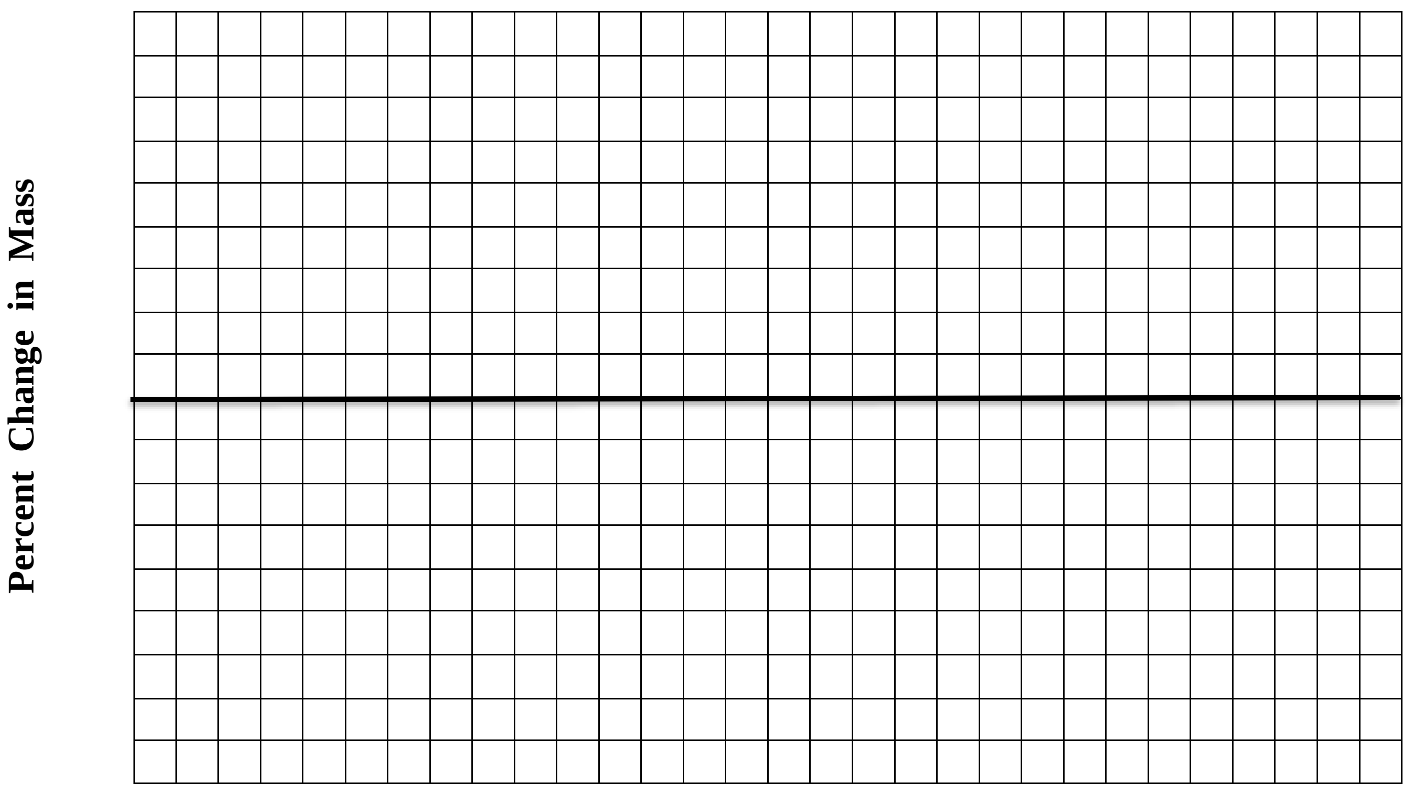


25. Zucchini cores placed in sucrose solutions at 27°C resulted in the following percent changes after 24 hours:

Sucrose Molarity	% Change in Mass
0.0 M	20%
0.2 M	10%
0.4 M	-3%
0.6 M	-17%
0.8 M	-25%
1.0 M	-30%

Graph the results below:

Title: ____



Molar Concentration of the Zucchini Cores = ____________ *M*

26. From the graph, determine the sucrose molar concentration equivalent to the molarity of the zucchini cells.

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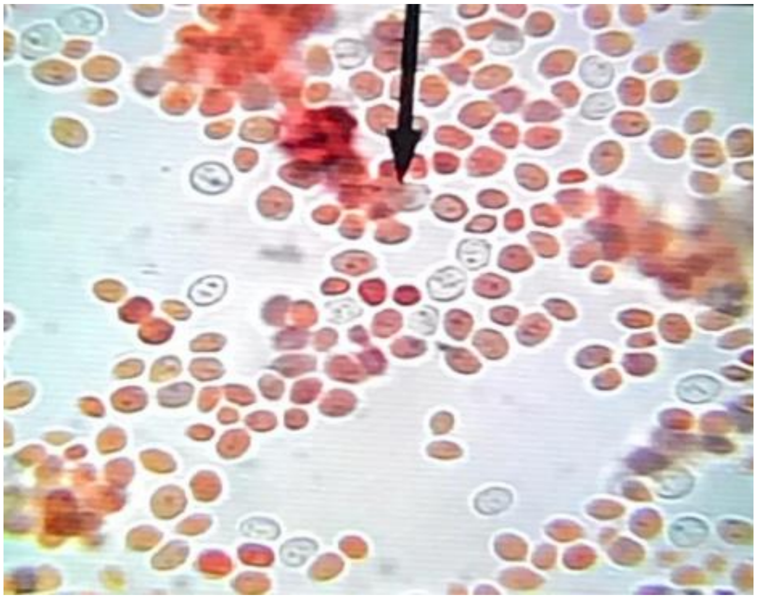
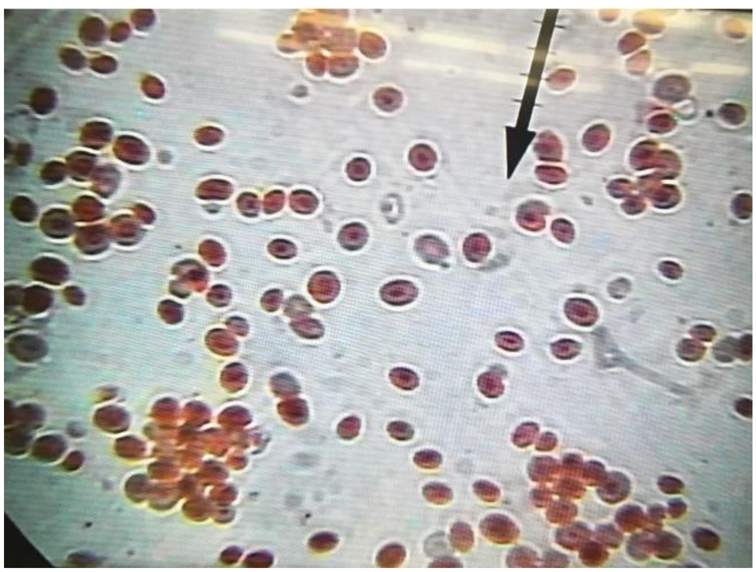
27. Calculate the percentage of yeast cells that contain the dye Congo Red in each picture.

<u>Living Yeast Cells</u>



<u>Boiled Yeast Cells</u>



Briefly explain your results.

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