Iron (Fe) is an essential element that is vital for virtually all organisms. Without iron, many cellular processes can be interrupted and the results can be catastrophic. In fact, iron deficiency is the primary nutritional disorder in the world, affecting two billion people. The following 18 questions focus on the importance of iron to biological processes.

1. Iron is acquired from our diets. In order to get into the blood stream, iron must pass through intestinal cells. Iron exists in either the ferric form (Fe^{3+}) or the ferrous form (Fe^{2+}). Assuming the concentration of iron in the intestines is high, what is the most likely way that iron passes through intestinal cell membranes?

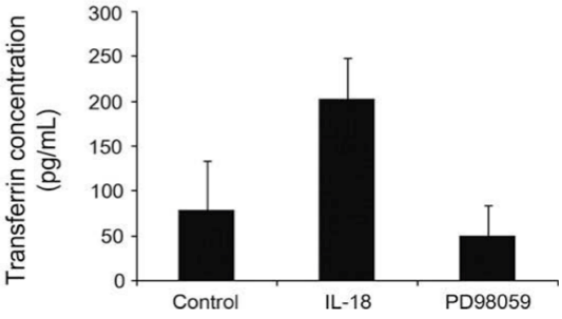
A. Via active transport
B. Via simple diffusion
C. Via phagocytosis
D. Via facilitated diffusion

2. Once iron passes through intestinal cells, it enters the bloodstream to circulate throughout the body. In order to travel through the blood, iron is bound to the glycoprotein transferrin. Transferrin is produced in liver cells (hepatocytes) and then secreted into the blood. How is transferrin produced in cells?

A. By ribosomes bound to the rough endoplasmic reticulum
B. By free ribosomes in the cytoplasm

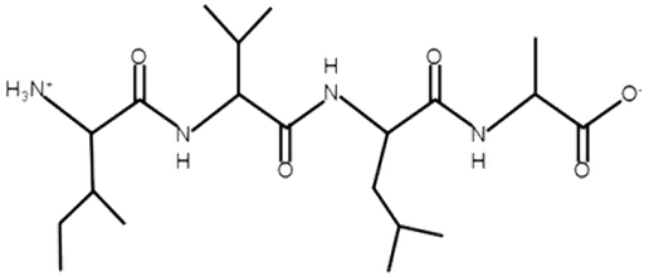
3. Researchers measured the effects of two molecules, IL-18 and PD98059, on the concentration of the transferrin protein in human liver cells. Which statement about these data could be true?

A. IL-18 is a transcription factor that binds to the enhancer for the transferrin gene
B. PD98059 is a drug that stimulates the action of enzymes that add acetyl groups to histones
C. IL-18 is an enzyme that cleaves the 3' tail of the transferrin primary transcript prior to it leaving the nucleus
D. PD98059 is an enzyme that enhances the activity of DNA-bending protein



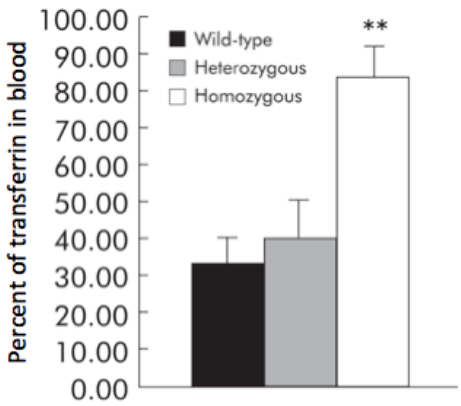
4.Where would you likely find this stretch of amino acids in transferrin?

A. Buried in the core of transferrin
B. On the surface of transferrin



5. Researches created genetic mice that either lack one copy (heterozygous) or two copies (homozygous) of the TfR gene. The TfR gene codes for the transferrin receptor which localizes to the plasma membrane. The researchers observed the data at the right. Assume there is a higher concentration of transferrin in the blood than inside of body cells. How does transferrin (and the iron that is bound to it) enter body cells?

A. Via simple diffusion
B. Via facilitated diffusion
C. Via pumping through an ion channel
D. Via a type of endocytosis

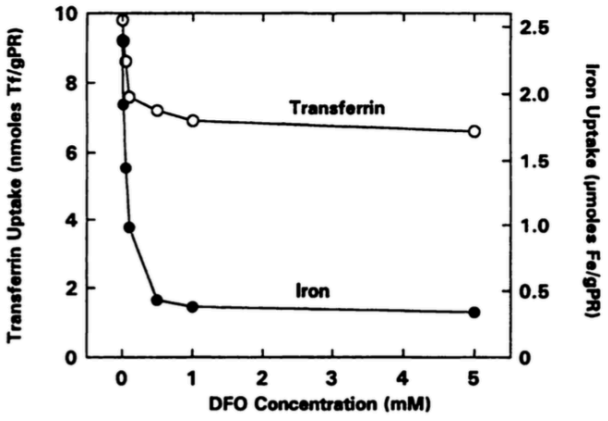


6. Mike (who has atransferrinemia) has a son (George) with his wife Molly, who does not have atransferrinemia and is not a carrier. George grows up and has a daughter (Sally) with his wife Grace, who does not have atransferrinemia and is not a carrier. What are the chances that Sally is a carrier for atransferrinemia?

A. 100%
B. 75%
C. 50%
D. 25%
E. 0%

7. Desferrioxamine (DFO) is a potent iron chelator, meaning that it binds strongly to iron and reduces the amount of iron that cells can use. The figure at the right shows data for transferrin and iron uptake into human melanoma cells at varying DFO concentrations. What can you conclude from these data?

A. Iron uptake and transferrin uptake are both positively correlated with DFO concentration
B. At 1 mM DFO, transferrin uptake is about 70 times higher than iron uptake
C. The percent decrease in transferrin uptake from 0 to 5 mM DFO is larger than the percent decrease in iron uptake from 0 to 5 mM DFO



8. Do the data from the figure for question 7 show correlation or causation between DFO concentration and iron uptake?

A. Correlation
B. Causation

9. Once in the cytoplasm, iron has many roles. If iron is not used immediately, it may be stored bound to the protein ferritin, which has 24 subunits. What is the highest level of protein structure that ferritin has?

A. Primary
B. Secondary
C. Tertiary
D. Quaternary

10. Iron is essential to cellular respiration, as it binds to many cytochromes in the electron transport chain. If iron is missing or at reduced concentrations in mitochondria such that the electron transport stops working, how might cellular respiration be affected?

A. ATP would not be produced at all
B. Oxygen would not be reduced
C. Glucose would not be oxidized
D. Pyruvate would not be produced

11. Iron acts as a cofactor for the enzyme catalase, which is present in peroxisomes where it acts to decompose hydrogen peroxide (H_2O_2) into water and oxygen. Which of the following would NOT be an effective way to assess the effects of adding catalase to this reaction?

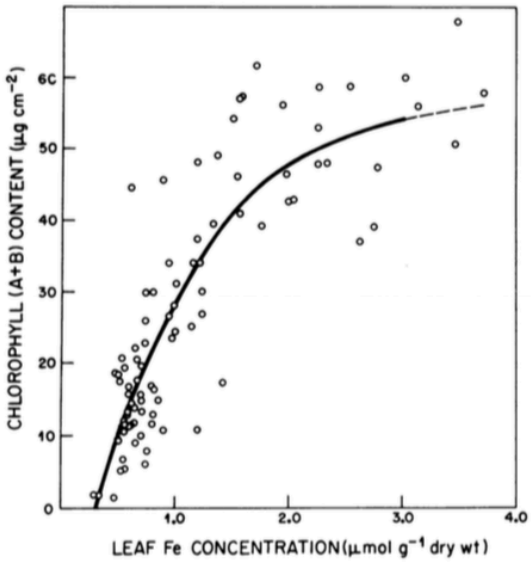
A. Measure the change in oxygen concentration with and without catalase
B. Measure the change in Gibb's free energy with and without catalase
C. Measure the change in activation energy with and without catalase

12. The enzyme ribonucleotide reductase (RNR) requires iron in order to convert ribonucleotides to deoxyribonucleotides. Which cellular process would NOT be able to occur without properly functioning RNR?

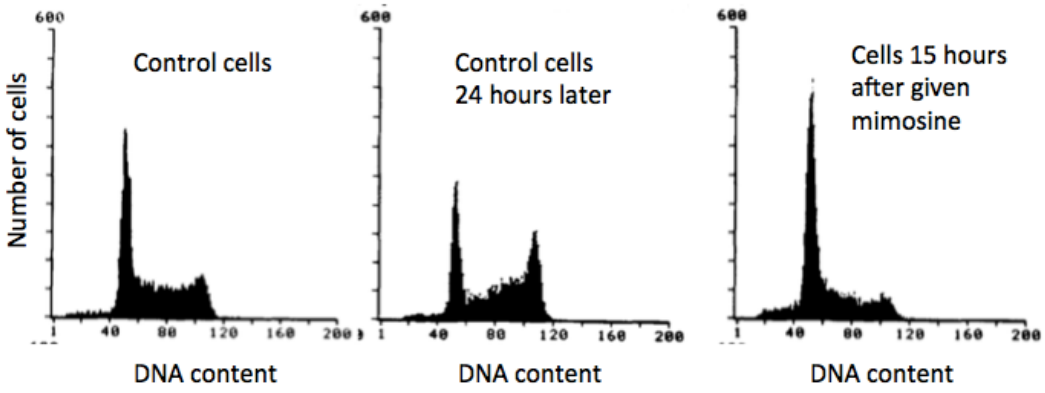
A. ATP hydrolysis
B. Transcription
C. Post-translational modifications
D. Mismatch repair
E. Alternative splicing

13. As stated in the introductory paragraph for this set of questions, iron is essential for all organisms, including plants. Researchers observed the data in the figure on the right when they gave plants varying amounts of iron (Fe). Using these data, what are you able to conclude about the effects of iron on plant cells?

A. The light reactions are likely dependent on iron
B. Photosystem I is likely dependent on iron
C. Photosystem II is likely dependent on iron
D. The Calvin cycle is likely dependent on iron
E. Oxidative phosphorylation is likely dependent on iron



14. Mimosine is a molecule similar to the amino acid tyrosine that acts as an iron chelator to remove iron from the cytoplasm. When researchers gave mimosine to human cells they observed the following results. Which of the following best explains their results?



A. Mimosine inhibits the formation of the mitotic spindle
B. Mimosine prevents DNA synthesis from occurring
C. Mimosine prevents separation of homologous pairs of chromosomes
D. Mimosine prevents chromosomes from condensing

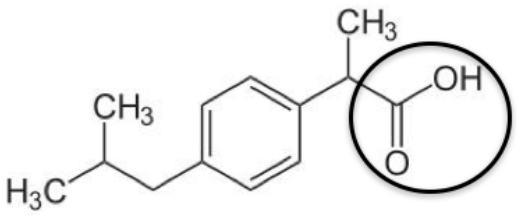
15. Cancer cells require more iron than normal cells, most likely because they divide so often. Based on your new knowledge of the effects of iron in cells, which of the following could be used as an effective anti-cancer drug?

A. A drug that blocks the action of iron chelators in cancer cells
B. A drug that results in improper trafficking of transferrin receptors in cancer cells
C. A drug that increases the activity of ribonucleotide reductase in cancer cells
D. A drug that promotes expression of transferrin in cancer cells

16. A drug has been developed that prevents cleavage of cohesin proteins and thus prevents sister chromatids from separating. What stage of mitosis would this drug act on?

17. Melanin is a pigment that is produced in skin cells. Many enzymes are required to produce melanin in the cytoplasm of skin cells. What cellular structure is likely found in large quantities in skin cells so that these enzymes can be produced?

18. Ibuprofen is a popular medication used to treat pain, fever, and inflammation. The molecular structure of ibuprofen is shown at the right. What type of functional group is circled?



19. Pyruvate dehydrogenase is an enzyme that converts pyruvate into acetyl CoA during pyruvate oxidation. What would be the effect of a pyruvate dehydrogenase inhibitor on the production of NADH, $FADH_2$, and CO_2? Assume that only pyruvate oxidation is affected and that other cellular processes proceed normally.

20. A DNA molecule has the following sequence: 3' – GATCGTTACGAGCTT – 5'. How many amino acids would this DNA molecule code for? Assume that it acts as a template.