Biology 12 **Name:** KEY

Cell Biology **Per:** _____ **Date:** _____

Chapter 2 – The Molecules of Cells

Complete using BC Biology 12, pages 20 - 61

2.1 Basic Chemistry pages 24 -26

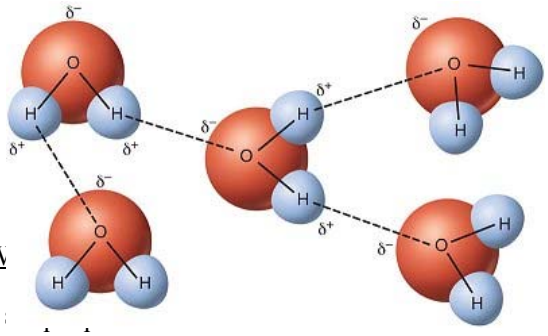
1. Only 92 [a] naturally occurring elements serve as the building blocks of all matter. Other elements have been "human-made" [b] and are not biologically important. Only six elements are basic to life and make up about 95% [c] of the body weight of organisms. The elements are carbon [d], hydrogen [e], nitrogen [f], oxygen [g], phosphorus [h], and sulfur [i] which can be remembered with the acronym CHNOPS [j].
2. Of the top six elements, which element is the **most** prevalent in organisms? oxygen
3. Explain how radiation can be both beneficial and harmful to humans. Radioactive isotopes are used in medical procedures (PET scan). However, high levels can harm cells, damage DNA, and cause cancer

2.2 Molecules and Compounds pages 26 - 29

4. Where do we get the energy to carry on our daily lives? chemical bond energy (when a chemical reaction occurs)
5. In biological systems, because they are 70-90 [a] % water, ionic [b] compounds exist primarily in a dissociated [c] state (they are dissolved) [c].
6. Molecules made up of only two atoms are always linear [a] while molecules with more than two atoms have a 3-dimensional [b] shape. The shapes of molecules are related to the structural [c] and functional [d] roles they play in organisms.
7. Name three molecules that rely on their shape to function properly.
   - hormones
   - antibodies
   - enzymes
8. Give an example of a(n)
   - non-polar covalent molecule: methane (CH_4)
   - polar covalent molecule: water (H_2O)
9. Weaker than an ionic or covalent bond, a hydrogen [a] bond is represented by a dotted line. Hydrogen bonding is NOT unique to water. Many biological molecules have polar covalent bonds involving and electropositive [b] hydrogen and an electronegative [c] oxygen or nitrogen.
10. Using a specific example, explain how the weakness of an individual hydrogen bond and the strength of numerous hydrogen bonds are utilized by organisms. Our body has enzymes which can easily break molecules apart by severing hydrogen bonds. However, DNA is strong due to many H-bonds (maintains its shape).

2.3 Chemistry of Water pages 29 - 32

11. Use three words or phrases to describe water:
    - polar
    - covalent
    - inorganic
12. Draw a picture showing the polarity of a water molecule and hydrogen bonding between water molecules.



Properties of W

13. Name the [illegible] the existence of life. Then explain the importance of each of the properties as it relates to the survival of an organism.
    a) High heat capacity: allows organisms to maintain their normal internal temperatures and are protected from rapid temperature changes
    b) High heat of vaporization: efficient way to release excess body heat (e.g. sweating or panting)
    c) Solvent: facilitates internal chemical reactions, transports materials in a dissolved state
    d) Cohesion & adhesion: transports through internal vessels, lubrication of joints, transport of water in plants
    e) Surface tension: some organisms are adapted to walking on water
    f) Solid is less dense than liquid: ice floats therefore bodies of water don't freeze solid in winter. Also, insulates bodies of water from sudden temperatures changes
14. Match the terms on the left to their correct description on the right.

D calorie	A. result of cohesive forces
E solute	B. molecules that can attract water ("water loving")
B hydrophilic	C. property of different molecules or surfaces clinging to each other
G hydrophobic	D. amount of heat energy needed to raise 1g of water by 1°C
F cohesive	E. the dissolved substances contained in a solution
C adhesive	F. like molecules sticking to each other
A surface tension	G. molecules that cannot attract water ("water fearing")

Acids and Bases

15. Acids are substances that release hydrogen ions (H+) when they dissociate in water.
    - Example: $HCl \rightarrow H^+ + Cl^-$
16. Bases are substances that either take up hydrogen ions or release hydroxide ions (OH^-).
    - Example: $NaOH \rightarrow Na^+ + OH^-$
17. What would the pH be of the following $[H^+]$ (moles per litre)?
    - $0.1 = 1 \times 10^{-1}$ = pH 1
    - $0.0001 = 1 \times 10^{-4}$ = pH 4
    - $0.000000001 = 1 \times 10^{-9}$ = pH 9
18. What is a **buffer**? Keeps the pH within a homeostatic range
19. The pH of our blood when we are healthy is always about 7.4 (a). If the blood pH drops to about 7 (b) then acidosis (c) results. If the blood pH rises to about 7.8 (d) then alkalosis (e) results. Both conditions can be life threatening (f).
20. Show the formula for one of the buffer systems used by the body to keep blood pH in balance.

$$H_2CO_3 \underset{\text{too acidic}}{\overset{\text{too basic}}{\rightleftharpoons}} H^+ + HCO_3^-$$

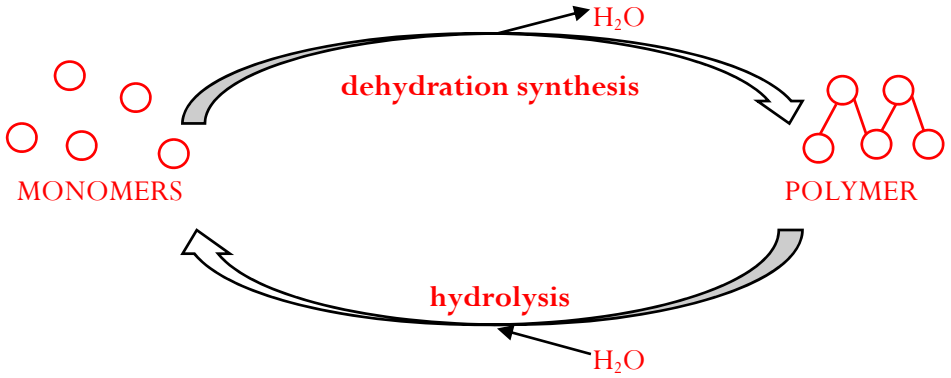
21. Why is a weakly dissociating acid/base a better buffer than a strongly dissociating one? Allows body to maintain homeostasis without "overcorrecting" and causing pH to swing too far in the opposite direction

2.4 Organic Molecules — pages 32 - 33

22. Organic molecules always contain carbon and hydrogen. Carbon atom has 4 electrons in its outer shell which it can share covalently with as many as 4 other atoms.
23. Define the following:
    - **functional group**: specific combination of bonded atoms that always react in the same way
    - **macromolecule**: contain many molecules bonded together
    - **monomer**: single organic molecule
    - **polymer**: linked monomers
24. Complete the table below.

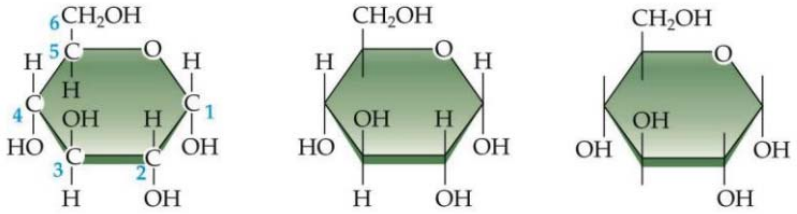
Polymer	Monomer
carbohydrate	monosaccharide (e.g. glucose)
lipid	glycerol (backbone) + fatty acids (up to 3)
protein	amino acid
nucleic acid	nucleotide

25. Diagram of **dehydration synthesis** and **hydrolysis** *(wait for simplified teacher diagram)*

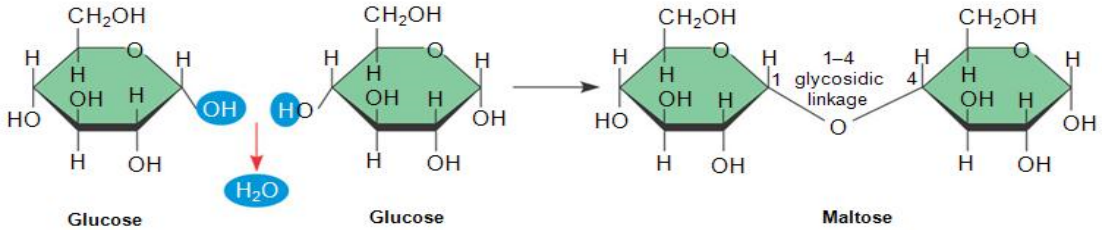


2.5 Carbohydrates pages 34 - 35

26. The main functions of carbohydrates:
    - quick fuel
    - short-term energy storage
    - structural role in woody plants, bacteria, and animals such as insects.
    - cell-to-cell recognition (some found on cell surface)
27. Characterized by the presence of atomic grouping H – C – OH [(a)] and the empirical formula **CH_2O** which is why the term "hydrates of carbon "[(b)] is often used.
28. Three ways to represent the structure of glucose (textbook figure 2.12)



29. If the number of carbon atoms in a molecule is low (from 3 - 7)[(a)] then the carbohydrate is a simple sugar [(b)] which is also known as a monosaccharide [(c)].
    - 5-carbon sugar = pentose
    - 6-carbon sugar = hexose
        1. glucose ($C_6H_{12}O_6$, blood sugar)
        2. fructose (found in fruits)
        3. galactose (found in milk)
30. A disaccharide contains two monosaccharides that have joined during a dehydration reaction
        1. glucose + glucose → maltose
        2. glucose + fructose → sucrose
        3. glucose + galactose → lactose
31. Diagram of two monosaccharides forming disaccharide (textbook figure 2.13)



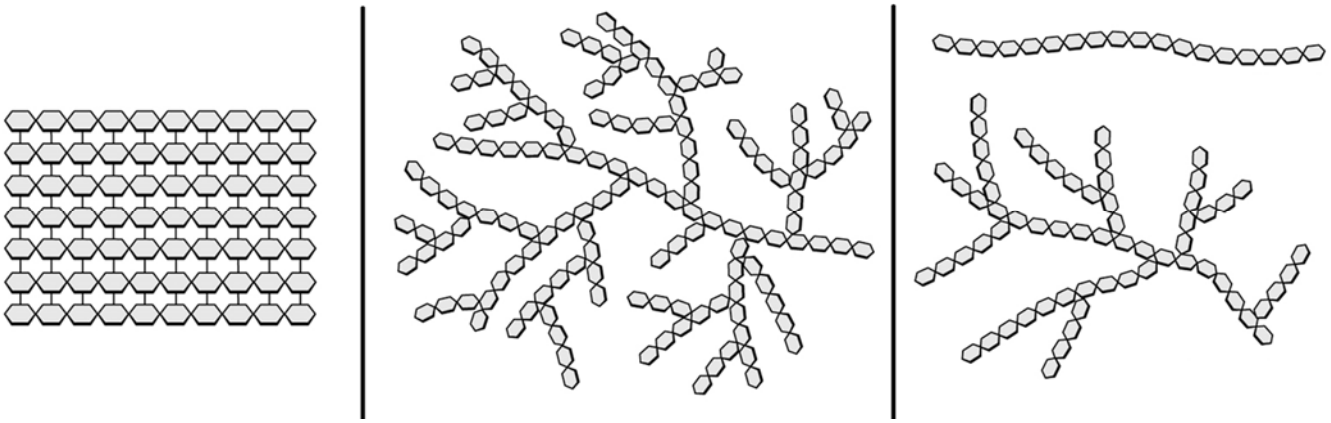
32. Carbohydrates that contain many glucose subunits are referred to as polysaccharides.

- Starch and glycogen are large storage forms of glucose found in plants and animals.
- Cellulose is found in plant cell walls
- Chitin is found in the exoskeleton of crustaceans and insects.

33. Match the terms on the left to their correct descriptions)on the right.

B & C starch	A. indigestible by humans, often referred to as dietary fibre
E & F glycogen	B. non-branched or slightly branched
A & D cellulose	C. high amounts found in flour and potatoes
	D. alternating up/down pattern of oxygen atoms between the glucose molecules
	E. highly branched
	F. created by the liver when the blood glucose levels rise above 0.1%

34. Identify each of the following as either **starch**, **glycogen**, or **cellulose**.



cellulose glycogen starch

2.6 Lipids pages 36 - 37

35. The main functions of lipids:

- Contain more energy per gram (long term)
- Energy storage molecules
- Phospholipids form the cell membrane
- Steroids, includes many types of hormones
- Insulate against heat loss
- Forms a protective cushion around major organs

36. All lipids DO NOT [a] dissolve in water as they are hydrophobic [b]

37. 1 glycerol molecule + 3 fatty acid molecules = triglyceride (neutral fat)

38. What is the difference between…

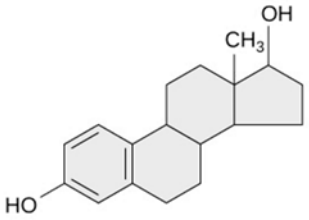
a) fats and oils? Fats: animal origin, solid at room temperature
Oils: plant origin, liquid at room temperature

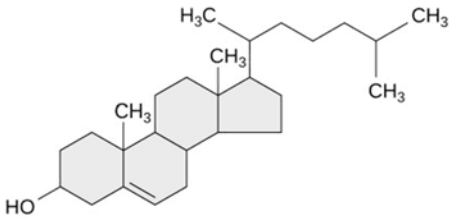
b) saturated, unsaturated, and trans fats?
Saturated: no double bonds, all possible bonds filled with H
Unsaturated: double bonds between carbon atoms
Trans fats: produced by hydrogenation, chemical addition of H (man-made, not found in nature)

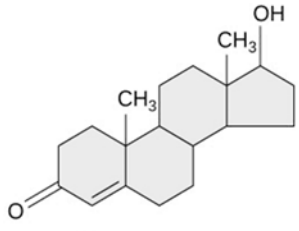
39. In a **phospholipid**, the third fatty acid is replaced by a polar phosphate group[(a)]. They differ from fats as they form a polar (hydrophilic)[(b)] head and a nonpolar (hydrophobic)[(c)] tail.

40. How are all types of steroids the same? different? All are composed of a backbone of 4 fused carbon rings but differ in the arrangement of atoms in the rings and the type of functional groups attached to them.

41. Identify the following steroids.

a. 

b. 

c. 

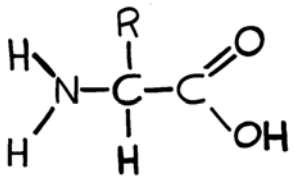
Estrogen Cholesterol Testosterone

42. Though we often think that cholesterol is "bad" for us in our diet, our bodies require it in a balanced quantity. What important functions does cholesterol serve?
Acts as a precursor to many other steroids (e.g. bile salts, estrogen, testosterone)
Component of the cell membrane (aids in stability)

2.7 Proteins pages 37 - 41

43. Central carbon atom bonded to hydrogen atom and three functional groups:

- amino group (-NH_2)
- carboxylic acid group (-COOH)
- R-group (differs by amino acid, 20 possibilities)

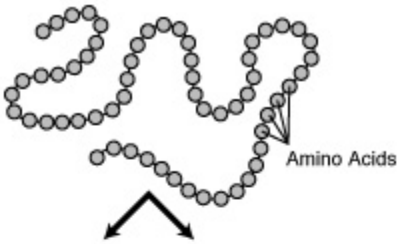


44. The main functions of proteins (the table on page 54 is very helpful)

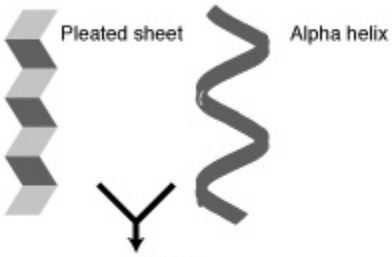
- **Structural**: keratin (makes hair and nails) and collagen (lends support to ligaments, tendons, and skin)
- **Movement**: actin & myosin (movement of cells and muscle contractions)
- **Transport**: in the plasma membrane they act as channels or carriers to allow substances to cross. Hemoglobin (transports oxygen in red blood cells)
- **Catalytic**: enzymes (speed up chemical reactions in the body)
- **Regulatory**: hormones (chemical messengers)
- **Defense**: antibodies (prevent infections and therefore maintain homeostasis)

45. What characteristic influences the structure, or shape, of a protein? The hydrogen bonding between the C=O of one amino acid and the N-H of another amino acid

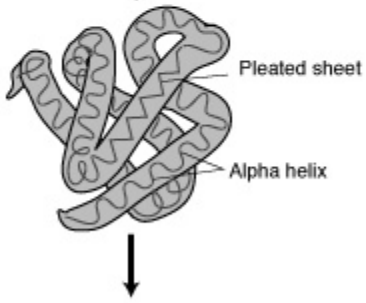
46. Proteins can have up to four levels of structural organization.



Primary structure: simple sequence of amino acids joined together by peptide bonds.



Secondary structure: hydrogen bonds pull amino acid chains into either **alpha helix** or **beta-pleated sheet**



Tertiary structure: is maintained by various types of bonding (hydrogen, ionic and covalent) among the R-groups. By virtue of the unique chemistry of each amino acid chain, kinks or bends occur and new bonds form holding into a specific 3D shape.

Quaternary structure: two or more tertiary structures associate together and function as a single unit.
Examples include hemoglobin and most enzymes

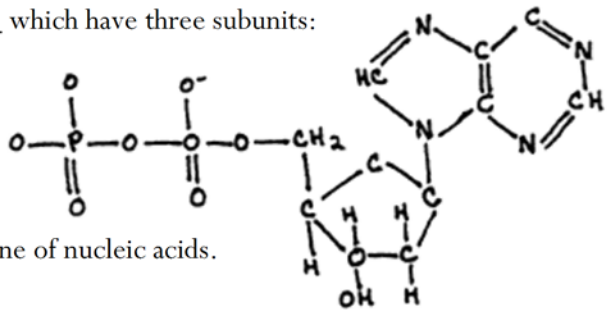
47. Proteins can differ in many ways including length [a], sequence [b], and structure [c] and chemical composition.
48. Define **denatured**: protein that has undergone an irreversible change in shape that effects its functioning
    - Possible causes: extremes in heat or pH
    - *Prion?* causes diseases such as Alzheimer's and Creutzfeldt-Jacob

2.8 Nucleic Acids — pages 41 - 45

49. The main functions of nucleic acids:
    - Stores genetic information
    - Transfers genetic information within the cell & in organism

50. Nucleic acids are made up of nucleotides which have three subunits:

- phosphate (phosphoric acid) **(B)**
- pentose sugar **(B)**
- nitrogenous base



51. Write a **(B)** next to the two subunits that make up the backbone of nucleic acids.

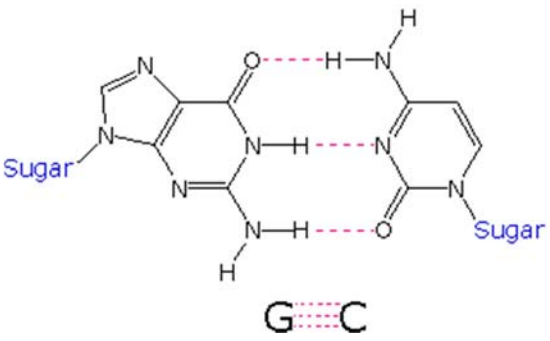
52. Complete the table.

	DNA	RNA
Full name	deoxyribose nucleic acid	ribonucleic acid
Sugar	deoxyribose	ribose
Bases	**A**denine, **T**hymine, **C**ytosine, **G**uanine	**A**denine, **U**racil, **C**ytosine, **G**uanine
Strands	2	1
Helix	Yes	No
Function	Specifies sequence of amino acids for creation of proteins	Makes ribosomes to aid in protein synthesis (mRNA, tRNA, rRNA)

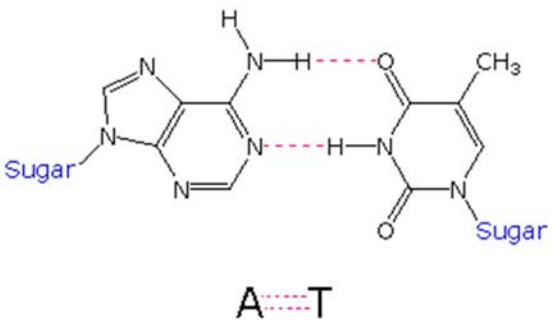
53. Why are A, T, C, G, and U called "bases"? their presence raises the pH of a solution

54. Explain the term **complementary base pairing** and why it is important. Bases only match in specific pairs (e.g. A-T and C-G). This ensures perfect replication and production of proteins.

55. Draw two different complementary base pairs. (textbook Figure 2.25c)



G C



A T

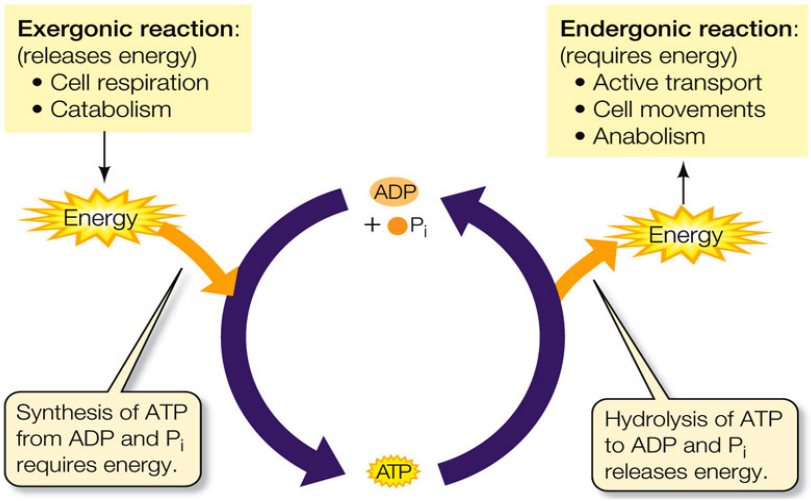
56. ATP or adenosine triphosphate is known as the universal energy currency of the cells of living systems and can be used for the following types of work.

Type	Example
Chemical work	synthesizes macromolecules
Transport work	pump substances across cell membrane
Mechanical work	muscle contraction, moving cilia & flagella

57. ATP is composed of
    - nitrogenous base (adenine)
    - 5 carbon sugar (ribose)
    - 3 phosphate groups

58. An input of energy is required to create ATP.
    - Where does it come from? breakdown of glucose
    - What is the reaction called? cellular respiration
    - What percentage of the free energy is transformed into ATP? 39%

59. Distinguish between an **endergonic** and an **exergonic reaction**. Use a diagram to help if needed.



Chapter 2 Review Questions — pages 56 - 61

1. d	11. d	21. a	31. d
2. c	12. c	22. b	32. b
3. d	13. c	23. b	33. c
4. d	14. b	24. b	34. a
5. c	15. c	25. d	35. b
6. b	16. b	26. a	36. c
7. c	17. b	27. b	37. a
8. c	18. b	28. a	38. a
9. d	19. b	29. d	39. d
10. d	20. b	30. a	

40. (a) 7,6 (b) 3 (c) 2,8,12,13,14 (d) 11 (e) 13 (f) 6,7
(g) 12 (h) 2 (i) 5 (j) 10 (k) 9 (l) 3,4
(m) 14 (n) 1,4,8,10,12,13,14 (o) 3,4 (p) 5

44. Hydrogen bond

45. Water is a polar molecule so O^- of one molecule is attracted to H^+ of another

47. Oxygen "holds" onto the electrons more

49. Good for quick energy, and can be stored as glycogen for later use

50. Because an H_2O is removed during dehydration synthesis

51. Dehydration synthesis

52. peptide

53. dipeptide (eventually a protein)

54. 9 (number of bonds)

55. disaccharide

56. H_2O

57. hydrolysis

59. (a) DNA has the "code" for protein synthesis

(c) monosaccharides bond together by dehydration synthesis to form polysaccharides

(f) polar molecules "stick" to each other (cohesion)

63. They have hydrophilic heads and hydrophobic tails

66. (b) liquid

72. Due to 20 different monomers and have 4 levels of structure

90. (a) body would start to use fat stores to get enough energy

(b) lipids

91. Body wouldn't have monomers to build proteins required by the body for regular functioning (e.g. enzymes, hormones, etc) which could result in body systems shutting down.

93.

Carbohydrates	Lipids	Proteins	Nucleic Acids	High Energy Compounds
polysaccharides	triglycerides	peptides	DNA & RNA	ATP
disaccharides	fatty acids	amino acids	nucleotides	nucleotide
monosaccharides	glycerol			phosphate group

You must now MARK the review questions using the answer key on pages 524 – 526!