# CHEM-102H: HONORS INTRODUCTION TO ORGANIC CHEMISTRY AND BIOCHEMISTRY

## Cuyahoga Community College

### Viewing: CHEM-102H : Honors Introduction to Organic Chemistry and Biochemistry

**Board of Trustees:**
2014-06-19

**Academic Term:**
Fall 2021

**Subject Code**
CHEM - Chemistry

**Course Number:**
102H

**Title:**
Honors Introduction to Organic Chemistry and Biochemistry

**Catalog Description:**
Study of the structure, properties, and function of carbon-based compounds. Introduction to biochemistry including structure, properties, and metabolism of proteins, carbohydrates, and lipids. Roles and structures of enzymes, vitamins, chemical messengers, deoxyribonucleic acid (DNA), and ribonucleic acid (RNA) in cellular function. Principles of structure and function will be applied to medicine and nutrition.

**Credit Hour(s):**
4

**Lecture Hour(s):**
3

**Lab Hour(s):**
3

## Requisites

**Prerequisite and Corequisite**
CHEM-101H Honors Introduction to Inorganic Chemistry, or departmental approval.

## Outcomes

**Course Outcome(s):**
Apply basic principles of organic chemistry to health careers or other advanced scientific studies.

**Essential Learning Outcome Mapping:**
Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

**Objective(s):**
1. Name organic compounds including alkanes, alkenes, aromatic, aldehydes, ketones, carboxylic acids, amines, amides, esters, ethers, alcohols, and thiols using International Union of Pure and Applied Chemistry (IUPAC) nomenclature and common names.
2. Compare the structures, formulas, and properties of organic molecules.
3. Examine the toxicity of compounds including alkaloids.
4. Relate the structure and function of organic molecules to the inhibition of enzymes.
5. Describe the structure and properties of vitamins and the role of vitamins in enzyme function.
6. Explain the medicinal uses of organic compounds including carboxylic acid derivatives and heterocyclic nitrogen compounds.

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**Course Outcome(s):**
Apply a fundamental knowledge of biochemistry when working in the health sciences or in other advanced scientific studies.

**Essential Learning Outcome Mapping:**

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

**Objective(s):**

1. Compare the composition and nature of DNA and RNA and explain the relationship of DNA and RNA to protein synthesis.
2. List the nature and properties of carbohydrates including monosaccharides, disaccharides and polysaccharides
3. Examine carbohydrate metabolism including glycolysis, the citric acid cycle, and the electron transport chain with the resultant production of ATP from ADP.
4. Relate lipid metabolism including the beta oxidation cycle of fatty acids with the citric acid cycle and the electron transport chain and the ATP calculation for a given fatty acid.
5. Describe protein metabolism including relationship to citric acid cycle, urea cycle, and gluconeogenesis.
6. Define the nature and properties of hormones and other chemical messengers
7. Relate the nature and properties of lipids to the formation of cell membranes.
8. Describe the nature of digestion including the related enzymes, resultant blood sugar levels, and the processes of glycogenesis and glycogenolysis.
9. Interrelate carbohydrate, lipid, and protein metabolisms, the effects of fasting, and the causes of positive and negative protein balance.
10. Examine the biochemistry and function of bodily fluids and the use of blood and urine in diagnosis and treatment of disease.
11. Describe the nature and properties of amino acids and proteins including zwitterion structure, amphoteric nature, isoelectric point, optical activity of amino acids and the primary, secondary, tertiary, and quaternary structures of proteins.
12. Explain the nature and properties of enzymes including the composition, specificity, function, and inhibition.
13. Demonstrate enzyme dysfunction in disease progession and the use of enzyme inhibitors as pharmaceuticals.

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**Course Outcome(s):**

Apply knowledge of organic chemistry and biochemistry to current scientific studies and everyday life.

**Essential Learning Outcome Mapping:**

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

**Objective(s):**

1. Describe the structure and function of organic molecules in rational drug design and combinatorial chemistry.
2. Examine the usage of organic chemistry in food chemistry and cosmetics.
3. Relate the properties of bioactive molecules to toxicology and pharmacology.
4. Demonstrate the use of genomics, proteomics, and metabolomics as diagnostic tools.

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**Course Outcome(s):**

Apply laboratory safety and fundamental laboratory skills to health careers and other scientific studies.

**Essential Learning Outcome Mapping:**

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.
Written Communication: Demonstrate effective written communication for an intended audience that follows genre/disciplinary conventions that reflect clarity, organization, and editing skills.

**Objective(s):**

1. Demonstrate laboratory safety, fundamental laboratory skills, and laboratory techniques.
2. Analyze experimental results by applying the fundamental concepts of chemistry and biochemistry.
3. Construct ball and stick models for the organic functional groups and cis-trans isomers as well as o,p,m isomers to determine three-dimensional nature of organic molecules.
4. Deduce the structures of organic molecules using representative chemical tests.
5. Distinguish between biomolecules such as amino acids, proteins, carbohydrates, lipids, and fatty acids using chemical tests.
6. Synthesize polymers and organic molecules such as aspirin.
7. Extract and characterize organic molecules from food sources.

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**Course Outcome(s):**

Analyze information from sources to reach an informed conclusion.

**Essential Learning Outcome Mapping:**

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Information Literacy: Acquire, evaluate, and use information from credible sources in order to meet information needs for a specific research purpose.
Written Communication: Demonstrate effective written communication for an intended audience that follows genre/disciplinary conventions that reflect clarity, organization, and editing skills.

**Objective(s):**

1. Identify information from non-scholarly and scholarly articles.
2. Evaluate information and information sources.
3. Use library and internet resources to explore a topic.

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**Methods of Evaluation:**

1. Exams
2. Cumulative final examination
3. Laboratory exam(s) and/or lab reports
4. Evaluation of laboratory skills
5. Oral presentations
6. Attendance and participation
7. Quizzes
8. Group projects
9. Homework assignments
10. Student papers and written reports

**Course Content Outline:**

1. Introduction to organic chemistry
   a. Properties of organic molecules
   b. Functional groups
   c. Isomers and conformers
   d. Drawing organic structures including condensed and line structures
   e. Types of organic reactions-addition, elimination, substitution, rearrangement
2. Alkanes and cycloalkanes
   a. Structures and properties of alkanes
   b. Reactions of alkanes
   c. Structures and properties of cycloalkanes
   d. Reactions of cycloalkanes
   e. International Union of Pure and Applied Chemistry (IUPAC) nomenclature of alkanes and cyclalkanes
3. Alkenes, alkynes, and aromatic compounds
   a. Properties of unsaturated hydrocarbons and aromatic compounds
   b. IUPAC nomenclature
   c. Cis-trans isomers
   d. Reactions of alkenes, alkynes, and aromatic compounds
   e. Markovnikov's Rule and reaction mechanisms
   f. Alkene polymerization
   g. Resonance
4. Alcohols, phenols, ethers, thiols, and halides
   a. IUPAC nomenclature and common names
   b. Physical properties
   c. Reactions
   d. Acid chemistry of alcohols and phenols
   e. Antioxidant properties of phenol compounds
   f. Formation of disulfide bonds and importance in protein and glutathione structure
   g. Applications of alkylhalides in medicine and environment
5. Aldehydes and ketones
   a. IUPAC nomenclature and common names
   b. Physical properties
   c. Reactions including hemiacetals and acetal formation
   d. Applications of formaldehyde, acetaldehyde, and acetone
6. Carboxylic acids and their derivatives

a. Structures and properties of carboxylic acids, amides, esters, and phosphoric acid derivatives
b. IUPAC nomenclature and common names
c. Reactions of the carboxylic acids and derivatives
d. Carboxylic acids and acid salts applications in cosmetics and food additives
e. Carboxylic acid derivatives in pharmaceutical industry including aspirin, acetaminophen, ibuprofen, lidocaine, and benzocaine
f. Formation and properties of polyamides, polyesters, and Kevlar

7. Amines
   a. Properties and IUPAC nomenclature
   b. Reactions and basicity of amines
   c. Solubility of amines and ammonium salts
   d. Properties and medicinal uses for nitric oxide, heterocyclic nitrogen compounds, ammonium salts, and alkaloids
8. Introduction to Biochemistry
   a. Classes of biomolecules including proteins, carbohydrates, lipids, and nucleic acids
   b. Functional groups in biomolecules
   c. Application of chemical principles in biochemistry
   d. Chiral compounds and enantiomers
9. Amino acids and proteins
   a. Amino acid structures and classifications
   b. Physical and chemical properties including acid-base properties
   c. Formation of peptide bonds
   d. Protein structure
      i. Primary
      ii. Secondary
      iii. Tertiary
      iv. Quaternary
   e. Intermolecular forces and disulfide bonds in determination of higher order protein structure
   f. Protein denaturation and peptide bond hydrolysis
   g. Protein dysfunction in medicine
10. Enzymes and vitamins
    a. Catalytic function of enzymes
    b. Classifications and properties of enzymes
    c. Specificity and turnover number
    d. Coenzymes and cofactors in enzyme function
    e. Models of enzyme action including lock-and-key and induced-fit
    f. Enzyme activity and effects of concentration, temperature, and pH
    g. Feedback, allosteric control, covalent modification, and genetic control in enzyme regulation
    h. Noncompetitive, reversible, and irreversible inhibition
    i. Water soluble and fat soluble vitamins
    j. Antioxidants
    k. Applications of enzymes in medicine including enzyme dysfunction in disease progression and enzyme inhibitors as pharmaceuticals
11. Chemical messengers
    a. Hormone properties and structures including amino acid derivatives, polypeptides, and steroids
    b. Interaction of hormones with receptors
    c. Mechanisms of epinephrine and anabolic steroids
    d. Neurotransmitters
    e. Agonists and antagonists
    f. Mechanisms of acetylcholine signal transduction
    g. Nucleic acids and protein synthesis
12. DNA and chromosomes
    a. Nucleic acid structure and properties
    b. Formation of nucleic acid polymers
    c. DNA structure and replication
    d. Double helix formation:  Watson-Crick model
    e. RNA structure and function
    f. Transcription
    g. Translation and protein synthesis
    h. Genetic code and codons

13. Carbohydrates
    a. D and L enantiomers of carbohydrates
    b. Fisher projections
    c. Structures and reactions of monosaccharides
    d. Modified monosaccharides
    e. Disaccharide and polysaccharide structures and properties
14. Lipids
    a. Structures, classifications, and properties of lipids
    b. Fatty acids and fatty acid esters
    c. Chemical reactions of triacylglycerols
    d. Phospholipids, glycolipids, and cholesterols
    e. Structure of cell membrane
    f. Passive and active transport across cell membranes
    g. Eicosanoids
15. Biochemical energy generation
    a. Energy and biochemical reactions
    b. Cells and organelles
    c. Catabolism and anabolism
    d. ATP and coupled reactions in metabolism
    e. Oxidation and reduction of coenzymes
    f. Citric acid cycle
    g. Electron transport chain
16. Metabolism of carbohydrates, lipids, and proteins
    a. Digestion of carbohydrates, triacylglycerols and proteins
    b. Glycolysis, glycogenesis, glycogenolysis, and gluconeogenesis
    c. Oxidation and biosynthesis of fatty acids
    d. Urea cycle
    e. Catabolism of amino acids
    f. Biosynthesis of nonessential amino acids
    g. Catabolism of Heme
    h. Metabolism in fasting and starvation
17. Chemistry and biochemistry of body fluids
    a. Intracellular and extracellular fluids
    b. Osmolarity, homeostasis, and fluid balance
    c. Blood, plasma, and blood clotting
    d. Blood gases
    e. Blood-brain barrier
    f. Urine formation, composition, and function
    g. Analysis of blood and urine in diagnosis and treatment of disease
18. Current research applications of organic chemistry and biochemistry
    a. Rational drug design and combinatorial chemistry
    b. Toxicology and pharmacology
    c. Genomics and proteomics
    d. Chemistry of food and cosmetics
19. Laboratory experiments
    a. Molecular modeling
    b. Classification and identification of alkanes, alcohols, phenols, aldehydes, ketones, carboxylic acids, esters, amines, and amides
    c. Polymer synthesis
    d. Preparation of aspirin
    e. Extraction and identification of fatty acids
    f. Examination of properties of carbohydrates, amino acids, and proteins
    g. Chromatographic separation of amino acids
    h. Effects of concentration, temperature, pH, and inhibitors on enzyme activity
    i. Preparation and properties of detergents
20. Information Literacy
21. a. Use the library resources to find information.
    b. Use internet resources to find information.

c. Determine if resources are scholarly or nonscholarly.
d. Use the information to research a scientific topic.

## Resources

McMurry, John, Mary Castellion, David S. Ballantine, Carl A. Hoeger, and Virginia E. Peterson. *Fundamentals of General, Organic and Biological Chemistry.* 6th ed. Upper Saddle River, NJ: Prentice-Hall, 2010.

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Bettelheim, Frederick A., and Joseph M. Landesberg. *Laboratory Experiments for Introduction to General, Organic, and Biochemistry.* 7th ed. Belmont: Brooks/Cole, 2010.

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Denniston, K. J., Joseph Topping and Robert L. Caret. *General, Organic, and Biochemistry.* 6th ed. New York: McGraw-Hill, 2008.

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Henrickson, Charles H., Larry C. Byrd, and Norman W. Hunter. *A Laboratory Manual for General, Organic, and Biochemistry.* 6th ed. New York: McGraw-Hill, 2008.

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Smith, Janice G. *General, Organic, and Biological Chemistry.* 1st ed. New York: McGraw-Hill, 2010.

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Bettelheim, Frederick A., William H. Brown, Mary K. Campbell, and Shawn O. Farrell. *Introduction to General, Organic, and Biochemistry.* 9th ed. Belmont: Brooks/Cole, 2010.

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Stoker, Stephen H. *General, Organic, and Biological chemistry.* 5th ed. Belmont: Brooks/Cole, 2010.

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Carlson, Lynn G. *Laboratory Manual for Stoker's General, Organic, and Biological Chemistry.* 5th ed. Belmont: Brooks/Cole, 2010.

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**Resources Other**

1. Kurnath, Norbert T., CCC Library Videotape Series for Chemistry 102. Parma, OH: Cuyahoga Community College, 1989-1996.

## Instructional Services

**OAN Number:**
Ohio Transfer 36 TMNS

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