Introduction to BioFuels

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A College Course on Biofuels

AgrowKnowledge™

The National Resource Center for Agriscience & Technology Education

Introduction to Biofuels

An introduction to combustion fuel made from nonpetroleum sources

Authored by: Ross Spackman, Ph.D.
for: AgrowKnowledge

This material is based upon work supported by Pioneer® and the National Science Foundation under Grant No. DUE-0434405. Any opinions, findings, and conclusions or recommendations expressed in this material are those of authors and do not necessarily reflect the view of Pioneer® or the National Science Foundation.

Introduction

This introductory college level biofuels course focuses on combustion fuels made from nonpetroleum sources and introduces the sources, processing, and social impacts of biofuel utilization.

Major funding for the development this AgrowKnowledge course was made possible by funding from Pioneer®, and the National Science Foundation. AgrowKnowledge is the ONLY center supported by the National Science Foundation that focuses exclusively on agriculture education. This course was developed for AgrowKnowledge by Ross Spackman, Ph.D. who was selected through an RFP process.

Dr. Spackman is a professor of Water Resource Management in the Agriculture program at the College of Southern, in Twin Falls, ID since 1994. Dr. Spackman is an active participant in AgrowKnowledge and has taught educators attending AgrowKnowledge workshops and conferences. At the core his educational approach is that the teacher is not the absolute center of knowledge and power but rather an information director who teaches students the basic concepts and then lets them expand on that knowledge in a direction most beneficial to them. A person won't fully understand a concept until they are able to teach someone else that concept.

The intent of this curriculum is to provide educators with the content necessary to teach a 3 credit hour course. The materials are divided into units and each unit includes;

- An introduction to the unit with unit objectives
- Worksheets to engage students in their own learning
- Lab activities to provide hands-on experiences
- Quizzes to test students knowledge of the material covered
- 3 Exams to test understanding of multiple units,

Notes about this curriculum:

1. A lot of cost analysis information on the Internet showing economics of producing different biofuels, but if it is more than 6 months old, it is outdated because of unprecedented grain price fluctuations.

2. Limited information is included about federal policy influencing biofuel development. A new president is certain to rearrange existing policies and the desire is to keep to the content of these materials as relevant as possible. Therefore, the author has stayed focused on the science. New technological developments will necessitate updating content.

3. The pictures and graphics include: photographs taken by the author, Microsoft clip art, and government material in the public domain. Other images are copyright the perspective owners.

COURSE SYLLABUS
BIOFUELS
3 credits
(2 hours lecture, 2 hours lab weekly)

Semester/year: **Instructor:**
Office Location: **Office Hours:**
E-Mail Address: **Office Phone:**

1. **Course Description:** This is an introductory course focusing on the scope of combustion fuels made from nonpetroleum sources (biofuels). The source, processing, and social impacts of biofuel utilization will be covered.

2. **Pre-requisites:** General biology and chemistry background is helpful.

3. **Required Textbooks and Supplies:** AgrowKnowledge/Pioneer PowerPoint series and lab guide.

4. **List pre-requisite skills:** College-level English, math, and computer competency for Internet searches and report preparation.

5. **Course Objectives:** Students will be able to describe:
   - How petroleum and bio-based fuels affect the global carbon cycle
   - The attributes of biofuels that make them suitable as a fuel for a specific application
   - Limitations of biofuels
   - Global impacts of biofuels on food and energy supplies
   - Technological advances and challenges to be overcome for wide-scale biofuel adoption

6. **Outcomes Assessment:** Mastery of the subject matter will be evaluated through written exams, quizzes, homework assignments, and computation-based laboratory exercises. A grade of 70% indicates the student generally understands the concepts presented.

7. **Policies and Procedures:**
   - Exams will be closed book and incorporate a variety of testing techniques; essay, multiple choice, true/false, matching, and fill-in-the-blank questions.
   - Quizzes will be closed book.
   - Homework assignments will be due at the start of class on the day indicated on the syllabus.
   - Cheating, dishonesty, and plagiarism will result in a penalty outlined in your college's student handbook or in the ethics statement.

8. **Grading Practices:**

			Percentage	Grade
Quizzes	8 x 10 pts. =	80	90-100%	A
Exams	3 x 100 pts. =	300	80-89%	B
Homework	5 @ 20 pts. =	100	70-79%	C
Lab Assn.	14@20 pts. =	280	60-69%	D
TOTAL		**760**	< 60%	F

9. **Library and Internet:** You will be required to do reading and conduct Internet reviews outside of class.

Topical Outline for the Course			
Week	**Classroom Lecture**	**Lab**	**Due**
1	Topic 1. Carbon in Our Environment		
	Topic 2. Introduction to Biofuels		
	LAB 1	1 Carbon Footprint	
2	Topic 3. Combustion Engines Part 1. Parts and Function		Quiz 1 Carbon and Introduction to Biofuels
	Topic 3. Combustion Engines Part 2. Turbines and Fuel Ratings		Worksheet 1 Chemistry of Petroleum
	LAB 2	2 Combustion Engines	
3	Topic 4. Alcohol Fuels Part 1.Attributes and History		Quiz 2 Combustion Engines
	Topic 4. Alcohol Fuels Part 2. Characteristics		
	LAB 3	3 Energy Value of Fuels	
4	Topic 4. Alcohol Fuels Part 3. Ethanol Production		Quiz 3 Alcohol Fuel Attributes and Characteristics
	Topic 4. Alcohol Fuels Part 4. Cellulosic Ethanol and Methanol		
	LAB 4	4 Yeast Respiration	
5	Topic 4. Alcohol Fuels Part 5. Butanol		Quiz 4 Production and Cellulose
	Topic 4. Alcohol fuels Part 6. Reports and Discussion		Worksheet 2 Ethanol Ethics Reports and Discussion
	LAB 5	5 Enzymes and Fermentation	
6	**Exam 1**		Introduction, Carbon, Engines and Alcohol
	Topic 5. Biodiesel Part 1.Petrodiesel		
	LAB 6	6 Proof and Distillation	

7	Topic 5. Biodiesel Part 2. Terms and Properties		
	Topic 5. Biodiesel Part 3. Making Biodiesel		Quiz 5 Petrodiesel. and Terms
	LAB 7	7 Making Biodiesel in the Lab with New Oil	
8	Topic 5. Biodiesel Part 4. Oil Sources		Worksheet 3 Food and Fuel
	Topic 5. Biodiesel Part 5. Straight Vegetable Oil (SVO)		Quiz 6 Making Biodiesel and SVO
	LAB 8	8 Making Biodiesel with Alternative Recipes l	
9	Topic 5. Biodiesel Part 6. Co-uses for Oilseed		
	Topic 5. Biodiesel Part 6.Second day		
	LAB 9	9 Building an Oilseed Press	
10	**Exam 2**		Biodiesel
	Topic 6. Gasification Part 1. Biomass		Worksheet 4 Biodiesel and Ethanol Comparisons
	LAB 10	10 Biomass Measurement	
11	Topic 6. Gasification Part 2. Producer Gas		
	Topic 7. Biogas Part 1. Biology		Quiz 7 Gasification
	LAB 11	11 Biogas	
12	Topic 7. Biogas Part 2. Feed Selection		
	Topic 7. Biogas Part 3. Fuel Value and Properties		
	LAB 12	12 Livestock Waste Management	
13	Topic 7. Biogas Part 4 Uses		Quiz 8 Biogas
	Topic 8. Mariculture Part 1. Algae Propagation		Worksheet 5 Biogas
	LAB 13	13 Aquatic Vegetation	
14	Topic 8. Mariculture Part 2. Fuel Conversion and Future Technology		
	Semester Review		
	LAB 14	14 Poster Presentation	
15	**Exam 3**		Gasification, Biogas, Mariculture, Fuel Cells

Carbon in Our Environment

Topic 1

An introduction to combustion fuels made from nonpetroleum sources

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Topic #: 1

Carbon in our Environment

Grade Level: 100/200 level college course

Subject(s):
Biofuels/renewable energy/agricultural production

Duration: One 50-minute session

Description: Students learn about the carbon cycle and its importance.

Goals: To learn why the carbon cycle influences research and development of biofuels and how it shapes public perceptions relating to climate change.

Objectives:
Students will be able to-

1. Describe long and short carbon pathways.
2. Explain how the carbon cycle works.
3. Identify segments of the carbon cycle that may affect climate change and explain how to alter those segments.
4. Understand how the U.S. economy can be strengthened through increased biofuel research and use

Materials:

1. PowerPoint lecture – Topic 1. Carbon in Our Environment – Lectures PowerPoints - Lecture 1 Carbon in our Environment.ppt
2. Internet searches

Procedure:
Follow the PowerPoint slide sequence

Assessment: Discussion on the implications of climate change and the possible solutions highlighted in the lesson can lead to good dialogue.

Special Comments: Notes beneath some of the slides will help the teacher explain some of the terms in the lesson.

Biofuels

Topic 1: Carbon in our Environment

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Elemental Carbon

- Carbon (C) is the chemical basis for all known life and is the fourth most abundant element in our universe.

Source: http://office.microsoft.com/en-us/clipart/default.aspx

Occurrence Examples

- Life processes like:

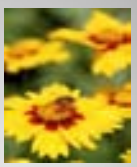
Photosynthesis –

6 CO_2 + 6 H_2O + (light energy)
=> $C_6H_{12}O_6$ + 6 O_2

--- and ---

Respiration –

$C_6H_{12}O_6$ + 6 O_2 => 6 CO_2 + 6 H_2O + Energy



Source: http://office.microsoft.com/en-us/clipart/default.aspx

Occurrence Examples, cont.

- Carbonates of calcium and magnesium
- Dissolved in water as CO_2 (carbon dioxide) and H_2CO_3 (carbonic acid)
- As minerals like diamond and graphite
- In the air as gases CO (carbon monoxide) CO_2, NO (nitrous oxide)

Source: http://office.microsoft.com/en-us/clipart/default.aspx

Occurrence Examples, cont.

- Hydrocarbons -organic compounds consisting entirely of carbon and hydrogen.
- Examples are:
  - Propane
  - Hexane
  - Butane

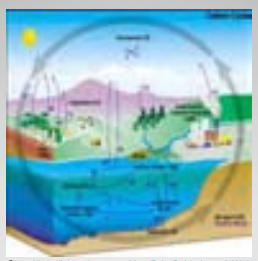
Source: http://office.microsoft.com/en-us/clipart/default.aspx

Carbon Cycles

- Carbon cycles through the water, land, atmosphere, and the Earth's interior in a major biogeochemical cycle.
- Two main C cycle categories:
  1. **geological-** measured in millions of years
  2. **biological/physical-** measured in days to thousands of years.

Source: USGS

Carbon Cycle



Source: http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon_cycle4.html

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Geologic Carbon

- C began accumulating during formation of Earth.
- Erosion processes move calcium and magnesium carbonate-bearing soil and rock into oceans where it accumulates on the floor.
- Subduction forces cause accumulations to be drawn into mantle.
- CO_2 can re-enter global cycle through volcanic eruptions.

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Last Ice Age about 20,000 years ago

- Geologic sediment samples predating life on Earth indicate atmospheric CO_2 levels were about 100 times above present levels but ice core samples indicate the levels to have been about half as great during the last ice age as now.

Source: http://office.microsoft.com/en-us/clipart/default.aspx

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Long term C cycling

- C has accumulated throughout history when photosynthesis has exceeded respiration and biomass accumulated to form oil and coal.
- This has removed C from the active global cycle.
- It is reintroduced during fossil fuel combustion.

Source: Microsoft clipart

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Short term C cycling

- Annually, photosynthesis and respiration move 1,000 times more C through the cycle compared to geological cycling.
- Several factors influence short term cycling.
  - Warm ocean water releases CO_2 while cold water causes accumulation.
  - Deforestation liberates biologically stored C.

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Anthropogenic (human) activities influence the C cycle

- Combustion of long cycle storage fossil fuels liberates C once held in storage.
- Deforestation and restoration practices change biomass diversity and density.
- Carbon banking initiatives promote C sequestration (intentional storage through prescribed agronomic or industrial practices).

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Human impacts, cont.

Biotechnology improvements allow marginal land to become more productive enabling more C storage.

Source: Microsoft Clipart

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Climate change…

…is often implicated as a consequence of increased atmospheric concentrations of C resulting in a condition called the greenhouse effect.

Source: Microsoft Clipart

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Greenhouse effect focal points

- The concentration of CO_2 and water vapor increases globally.
- These gases trap heat that would normally radiate back into space much the same way a greenhouse glass pane does.
- Higher atmospheric CO_2 levels result in higher global temperatures.

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Causes?

- Natural factors, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun.
- Natural processes within the climate system
  - e.g. changes in ocean circulation
- Human activities that change the atmosphere's composition and the land surface
  - e.g. through burning fossil fuels
  - e.g. deforestation, reforestation, urbanization, desertification, etc.

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Carbon-based currency

- Not only is C the backbone of organic life, but is the primary societal issue facing world populations.
- In the U.S., western Europe, Japan, China, and other rapidly developing countries, hydrocarbons run the economic machinery.
- Manufacturing, transportation, processing, heating and cooling are all reliant on abundant and cheap hydrocarbon fuels

Source: Microsoft clipart

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Carbon-based currency, cont.

- The economic law of supply and demand dictates that when something is abundant, it is cheap and when in short supply, more expensive. Such is the case with fuel.
- Two main forces responsible for decreased supplies are-

  1) increased demand and
  2) political instability

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Increased Demand

- World demand for fossil fuels has decreased supplies and prices have risen to all time highs for crude oil.
- China's dependence on oil is rapidly gaining on that of the U.S.

Source: http://office.microsoft.com/en-us/clipart/default.aspx

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Political Influences

- Problems with supply have caused price increases:
  - Middle Eastern wars
  - Corrupt governments
  - Hijacking oil shipments (pirates in Nigeria and elsewhere)
  - Resistance to further drilling off shore and in Alaska

Source: http://office.microsoft.com/en-us/clipart/default.aspx

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What can be done?

- Are there solutions for human influenced climate change, shrinking supplies of hydrocarbon fuels, and politically volatile energy markets?
- **YES!!!!**
- Answer- Conservation of present energy supplies, education, research & development of **renewable BIOFUELS**.

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Solutions

- **Conservation of energy** is the cheapest and easiest short-term solution to reducing CO_2 emissions and the need for more fuel.
- **Educating students** in math and science will enable us to: develop more efficient short-cycle fuels from plants (biofuels) and minimize further liberation of C from fossil fuels.

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Solutions, cont.

- Biofuel **research and development** techniques allow use of C already in global circulation.
- Biofuel **technology** will lessen our dependence on foreign oil and reduce the pressure for development of oil reserves in environmentally sensitive areas.

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Biofuel Champions-organizations that promote biofuels.

- AgrowKnowledge
- Pioneer Hybrid
- 25 x '25 Initiative
- National Renewable Energy Laboratory
- Many others!

Source: Microsoft Clipart

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- A national network of educators who:
  - Grow educational and business partnerships that strengthen math, science and technology skills of college agriculture students
  - Deliver high quality professional development workshops and curriculum to secondary and postsecondary educators
  - Incorporate new and emerging technologies into agriculture, food and natural resources programs; responsive to agriculture industry employment opportunities

http://www.agrowknowledge.com/

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Pioneer Hi-Bred International, Inc., a DuPont business, is the world's leading developer and supplier of advanced plant genetics to farmers worldwide.

- Pioneer seeks to increase customer productivity, profitability and develop sustainable agricultural systems for people everywhere.
- Innovative and customer-focused, Pioneer is a leader in the agriculture industry and upholds the highest standards.
- Headquartered in Johnston, Iowa, Pioneer provides services to customers in nearly 70 countries.

http://www.pioneer.com/web/site/portal/

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25x'25 Initiative

This initiative outlined by forward thinking agricultural scientists and policy makers states that by 2025, America's working lands will provide 25 percent of the total energy consumed in the United States while continuing to produce abundant, safe and affordable food, feed, and fiber.

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- The National Renewable Energy Laboratory (NREL), located in Golden, CO as part of the U.S. Dept. of Energy, is the United States' primary laboratory for renewable energy and energy efficiency research and development. Established in 1974, NREL began operating in 1977 as the Solar Energy Research Institute.
  - It was designated a national laboratory of the U.S. Department of Energy (DOE) in September 1991 and its name changed to NREL.
  - NREL is the principal research laboratory for the DOE Office of Energy Efficiency and Renewable Energy (EERE) which provides the majority of its funding.
  - Other funding comes from DOE's Office of Science and Office of Electricity Transmission and Distribution.

http://www.nrel.gov/

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Resources

- http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon_cycle4.html
- http://www.atimes.com/atimes/Southeast_Asia/FH11Ae02.htmlhttp://www.atimes.com/atimes/Southeast_Asia/FH11Ae02.html
- www.25x'25.org
- www.nrel.gov

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Introduction to Biofuels

Topic 2

An introduction to combustion fuels made from nonpetroleum sources

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Lesson Plan #: 2

Introduction to Biofuels

Grade Level: 100/200 level college course

Subject(s): Biofuels/renewable energy/agricultural production

Duration: One 50-minute session

Description: It is helpful if students understand the similarities and differences between different fuel types and how to compare the energy values of different fuels.

Goals: To learn the chemical differences between petroleum and bio-based fuels.

Objectives:
Students will be able to-

1. Explain what crude oil is and its origin
2. Explain how fractional distillation works
3. Describe different types of biofuels
4. Understand the basic differences in chemical bonds that make fuels have differing energy characteristics.

Materials:

1. PowerPoint slides – Topic 2. Introduction to Biofuels – Lectures PowerPoints - Lecture 2 Introduction to Biofuels.ppt
2. Lab 1. Carbon Footprint – LABS - LAB 1 Carbon Footprint.pdf
3. Internet searches

Procedure:
Follow PowerPoint slides.

Assessment:
Students will take a short summary quiz at the end of class that will not be graded.

Special Comments: none

Biofuels

Lesson 2. Introduction to Biofuels

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What is crude oil?

- A naturally occurring substance composed of hydrogen and carbon (hydrocarbon) usually found underground in certain rock formations but sometime above ground too.
- Formed over millions of year from the combined force of overlying sediment and heat acting on fossilized organic remains of tiny marine plants and animals.
- Usually natural gas and saline water are associated with oil deposits.
- Sometimes found in semi-solid form as tar sand which is less easily refined than liquid crude oil.

How and where is oil found?

- Watch this video from the American Petroleum Institute:

http://www.api.org/story/

Crude oil measurement

- Original oil storage containers were wooden barrels which stored 42 US gallons (159 liters).
- Sometimes measured in tons.
  - **1 ton = 7.33 barrels** but may vary depending on specific gravity of oil

What fuel is in a barrel of crude?

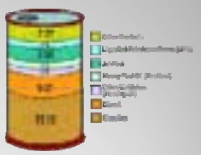
- Without refining, crude oil itself is of limited use.
- Some products made from the base or *crude* oil include:
  - Gasoline
  - Liquefied petroleum gas (LPG)
  - Naphtha- a feedstock for gasoline production
  - Kerosene
  - Gasoil
  - Fuel oil
  - Lubricants
  - Asphalt
- Many other substances are made using petroleum bases:
  - Plastics
  - Synthetic fibers
  - Synthetic rubbers
  - Detergents
  - Chemical fertilizers
  - Perfumes
  - Insecticides

Simple Distillation

- Crude oil is comprised of a mixture of hydrocarbons that can be separated by heat in a distillation column into various *fractions*.
- The lightest products boil off and are captured in the distillation column at the lowest temperatures.
- Heavier fractions (more complex C chains) can be “cracked” or broken into smaller, simpler units.

Barrel of Crude Oil

- **Note:** A 42-U.S. gallon barrel of crude oil yields between 44 and 45 gallons of petroleum products.
- These totals are greater than 42 gallons due to processing gain.



Source: Energy Information Administration

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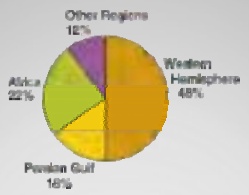
U.S. Petroleum Imports



U.S. Petroleum Net Import Sources, 2007

Source: Energy Information Administration

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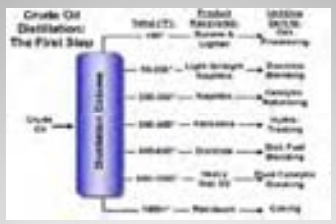
Distillation



Source: Energy Information Administration

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Hydrocarbon names based on three C bonding arrangements

1. Alkanes contain only carbon-carbon single bonds. Named by combining a prefix that describes the number of carbon atoms in the molecule with the root ending "ane".

- Properties
  - All combine with oxygen to produce carbon dioxide and water vapor
  - $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$ Combustion of methane
  - Flammable
  - Good fuel
  - Low boiling point

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The Alkanes

Carbon Atoms	Prefix	Alkane Name	Chemical Formula	Structural Formula
1	Meth	Methane	CH_4	CH_4
2	Eth	Ethane	C_2H_6	CH_3CH_3
3	Prop	Propane	C_3H_8	$CH_3CH_2CH_3$
4	But	Butane	C_4H_{10}	$CH_3CH_2CH_2CH_3$
5	Pent	Pentane	C_5H_{12}	$CH_3CH_2CH_2CH_2CH_3$
6	Hex	Hexane	C_6H_{14}	…
7	Hept	Heptane	C_7H_{16}	
8	Oct	Octane	C_8H_{18}	
9	Non	Nonane	C_9H_{20}	
10	Dec	Decane	$C_{10}H_{22}$	

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Hydrocarbon, cont.

2. Alkenes consist of molecules that contain at least one double-bonded carbon pair and follow the same naming convention used for alkanes. A prefix describes the number of C atoms and name ends with “ene”.
   - The chemical formula for the simple alkenes follows the expression C_nH_{2n}.
   - Because one of the carbon pairs is double bonded, simple alkenes have two fewer hydrogen atoms than alkanes.

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Hydrocarbon, cont.

3. Alkynes contain at least one triple-bonded carbon pair. A prefix denotes number of C atoms and name ends with "yne" to denote the triple bond.
   - The chemical formula for the simple alkynes follows the expression C_nH_{2n-2}

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Alcohol

- Alcohols are compounds in which one or more hydrogen atoms in an alkane have been replaced by an -OH group.
- This link will help you with deciphering the names of alcohols:

  http://www.chemguide.co.uk/organicprops/alcohols/background.html
- Used as fuel, beverages (ethanol), antiseptics, solvents, antifreeze (ethylene glycol), medicinal drugs, perfumes, hand sanitizers, and preservatives among others.

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Main types of fuel alcohol

1. Methanol (methyl alcohol, wood alcohol
   - -can cause blindness and death if ingested
   - -used as car racing fuel
2. Ethanol (ethanol, ethyl alcohol)
   - -used in beverages
   - -can be used as racing fuel but not as common as methanol
   - -heavily taxed by federal govt. unless **denatured**
3. Butanol (butyl alcohol)
   - -emerging as a promising automotive fuel
   - -used in solvents and paint products
   - All alcohol fuels can be made through natural fermentation processes but can be derived from petroleum too.
   - Alcohols from fermentation are called **BIOFUELS**.

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Denaturants in fuels

- Something added to make the alcohol unfit to drink without destroying its usefullness, especially regarding ethyl alcohol.
- Denatonium, usually available as denatonium benzoate (under trade names such as **Bitrex or Aversion**) and as denatonium saccharide, is the most bitter compound known to date.
- Methanol or gasoline may also be used.

Source: Microsoft Office 2007 Clipart

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Diesel

- A petroleum derived fuel with a higher boiling point than gasoline or ethanol.
- It contains more energy per unit volume than gasoline (energy dense).
- A standard fuel in trucking and heavy equipment use.
- When made from vegetable oil or animal fat, it is called biodiesel, another **BIOFUEL**.
- It can be a direct replacement for petroleum diesel in some applications.

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Biogas

- Another BIOFUEL derived from anaerobic decomposition of vegetative matter.
- The **flammable** portion is **methane** which is commercially processed from crude oil.

Source: Microsoft Office 2007 Clipart

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Energy density for select fuels

Material	By Volume	By Mass
Liquid Hydrogen	2,600 Wh/l	**39,000 Wh/kg**
Propane	6,600 Wh/l	13,900 Wh/kg
Butane	7,800 Wh/l	13,600 Wh/kg
Heating Oil	10,400 Wh/l	12,800 Wh/kg
Diesel Fuel	**10,700 Wh/l**	12,700 Wh/kg
Gasoline	9,700 Wh/l	12,200 Wh/kg
Liquid natural gas(-160°C)	7,216 Wh/l	12,100 Wh/kg
Ethanol	6,100 Wh/l	7,850 Wh/kg
Methanol	4,600 Wh/l	6,400 Wh/kg

Source- http://everything2.com/index.pl?node=Energy%20density

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Energy density

- Wh/l or kg means – watt hours per liter or kilogram.
  - When weight is at a premium, select fuels that maximize density with minimal mass.
  - This is why hydrogen is used as a space shuttle fuel instead of diesel which has a higher fuel value per volume as noted on the previous slide.

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Other energy measurement units

- British Thermal Unit (BTU) is a unit of energy used in the power, steam generation, and heating and air conditioning industries.
  - The official metric equivalent is the joule (J).
- Approximately-1 BTU is amount of heat required to raise one pound (one pint) of water 1 degree F.
- 5000 BTUs will boil ½ gallon water for 20 minutes.
- See website at end of lesson for more energy factors.

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Resources

- Information about OPEC countries and how the organization operates: www.opec.org
- http://www.sciencenetlinks.com
- Review of basic atomic structure and theory:
  http://www.school-for-champions.com/science/atom.htm
- Government information on the petroleum industry: http://www.eia.doe.gov/
- http://science.howstuffworks.com/oil-refining.htm
- Basic organic chemistry:
  http://www.visionlearning.com/library/module_viewer.php?mid=60
- Resource for energy values:
  http://bioenergy.ornl.gov/papers/misc/energy_conv.html

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BIOFUELS
LABORATORY EXERCISE 1
CARBON FOOTPRINT

20 points possible 2 pts each question Name_____

Use this website to answer the questions.
http://www.epa.gov/climatechange/emissions/ind_calculator.html

1. What is your calculated waste emissions before recycling? _____
2. What is your calculated waste emissions after recycling? _____
3. Realistically, if you committed to additional recycling, how much would that reduce your emissions? _____
4. Using the *fuel economy website* link on this website then the *cars energy impact score* link, what is your car's carbon footprint score?_____ How many barrels of oil used annually?_____
5. Watch any two of the videos on the *fuel economy website* link. What surprised you the most from what you learned?
   _____
   _____
   _____
6. Does anyone in your family own a hybrid vehicle? Refer to the same fuel economy website link and select a hybrid you would like to own. What features make it desirable?
   _____
   _____
   _____
   _____
7. How much would this vehicle cost new or used?_____ cite your reference
8. How many incandescent light bulbs could you replace in your residence with Energy Star bulbs? _____ How many pounds CO_2 would this avoid? _____
9. Do you have an Energy Star refrigerator? _____. If not, how many pounds of CO_2 would a replacement save? _____
10. What area of your carbon footprint can you reduce to the greatest degree?
    _____

BIOFUELS
Quiz 1
Carbon and Introduction to Biofuels

10 points **Name**_____

1. What element is the fourth most abundant in our universe?
a) nitrogen b) carbon c) hydrogen d) helium

2. Hydrocarbons contain mainly-
a) hydrogen and carbon b) hydrogen and oxygen c) water and oxygen
d) nitrogen and zinc

3. Combustion of fossil fuels results in release of _____cycle carbon into the atmosphere.
a) long b) short c) medium d) motor

4. _____ is often implicated as a consequence of increased atmospheric concentrations of C resulting in a condition called the greenhouse effect.
a) globalization b) climate change c) geysers d) global cooling

5. _____ is the cheapest and easiest short-term solution to reducing CO_2 emissions and the need for more fuel.
a) building nuclear power plants b) drilling oil wells c) buying new cars
d) conservation of energy

6. Usually natural gas and _____are associate with crude oil deposits.
a) saline water b) gold c) plutonium d) methoxide

7. One barrel of oil is equivalent to about how many US gallons?
a) 35 b) 42 c) 50 d) 68

8. A_____is used to separate the various fractions of fuel from crude oil.
a) distillation column b) refractometer c) hydrometer d) cannula

9. _____is used to make ethyl alcohol unfit to drink.
a) ethanol b) fructose c) yeast d) denaturant

10. Which fuel is the most energy dense by mass?
a) gasoline b) liquid hydrogen c) propane d) butane

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