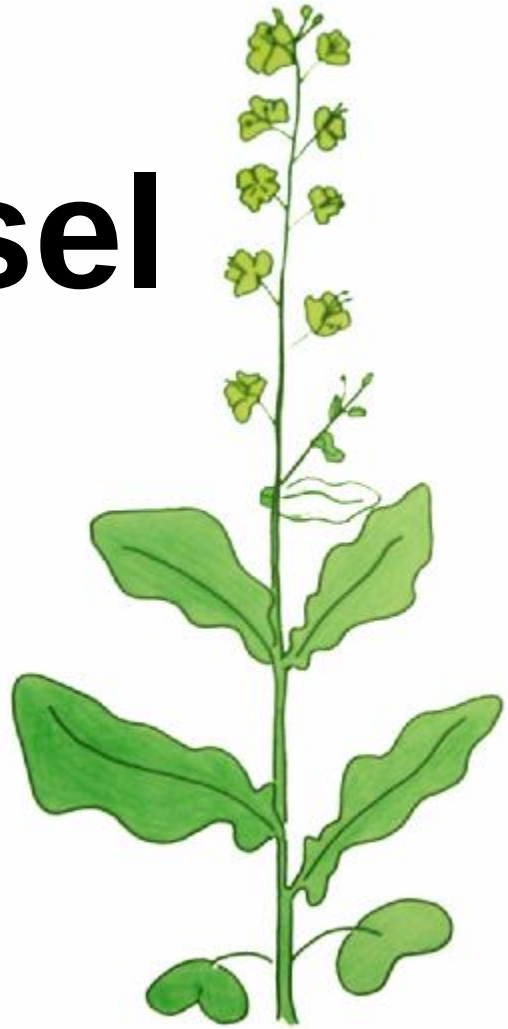
Brassica Biodiesel

using power from the sun for fuel



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Objectives

Introduce a integrative curriculum using Wisconsin Fast Plants, biodiesel production and Bottle Biology

The goal of the EENC workshop is to generate ideas for educators using these materials to help teach about renewable fuels and the issues surrounding the impact and integration of using these fuels in our society.

The unit, I hope integrates biology, chemistry, physics and provides a unique experiential approach to teaching this subject.

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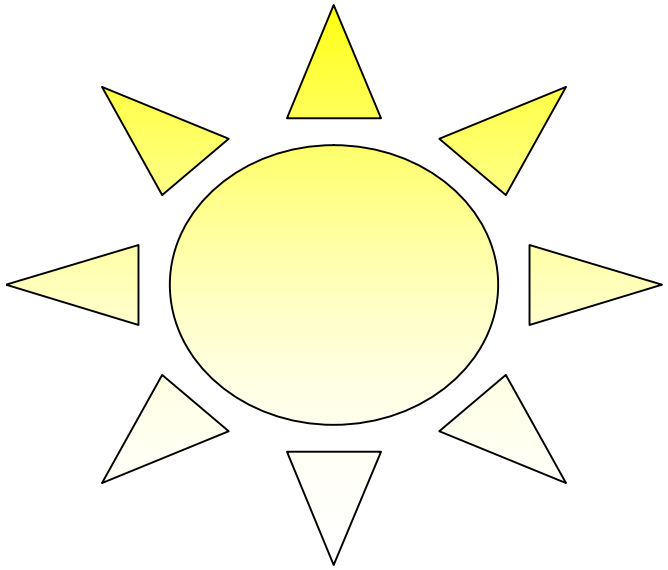
How are these three things connected?



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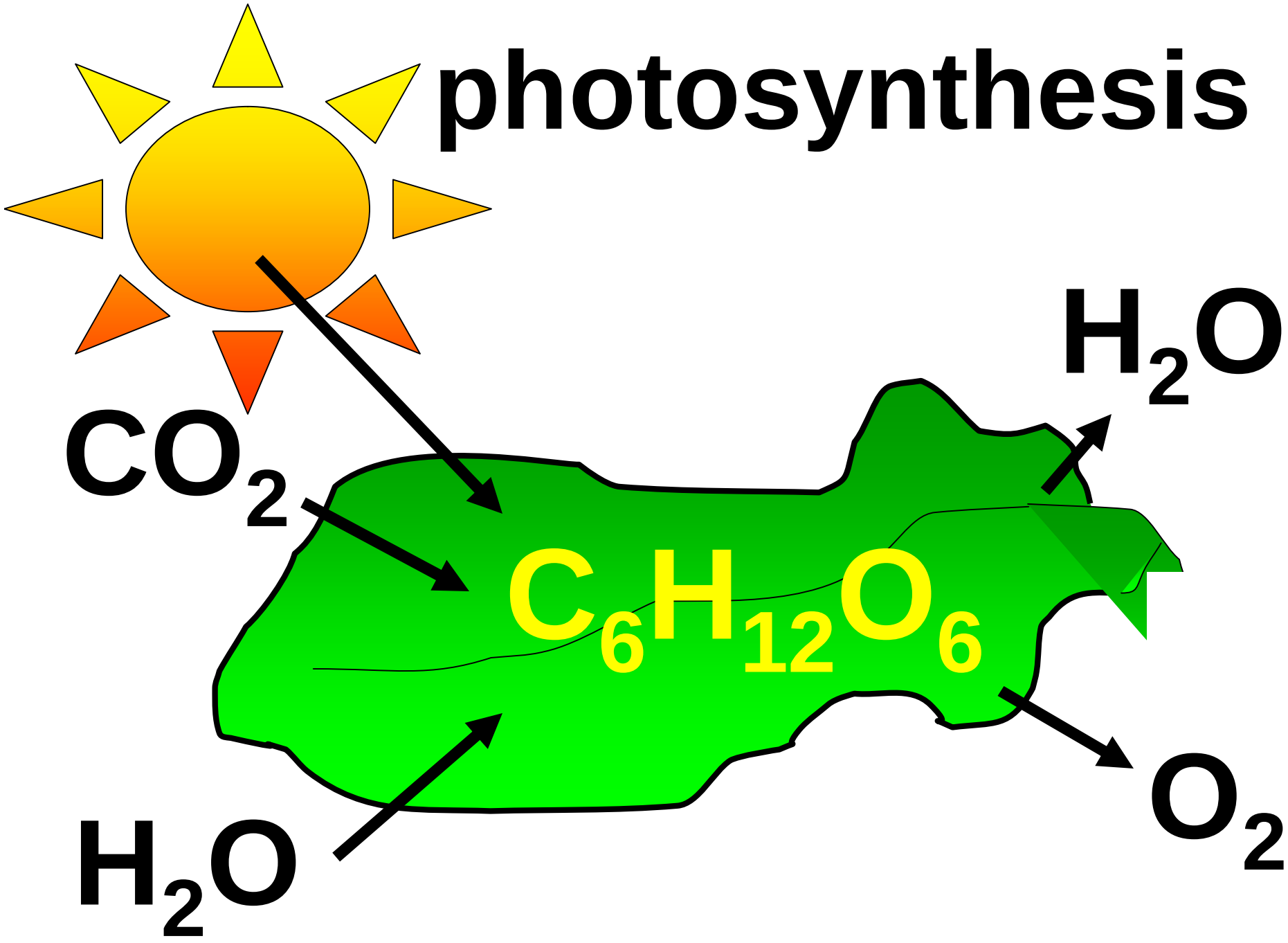

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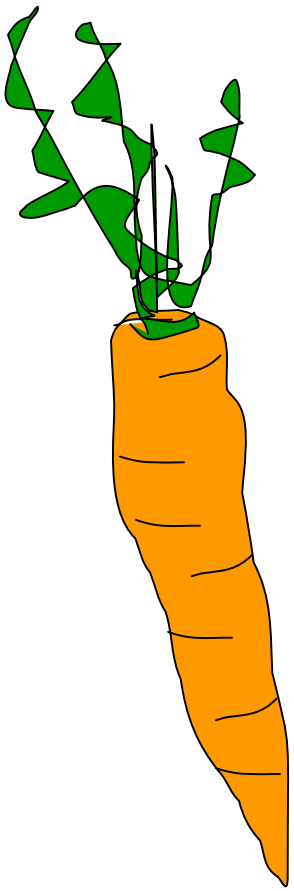
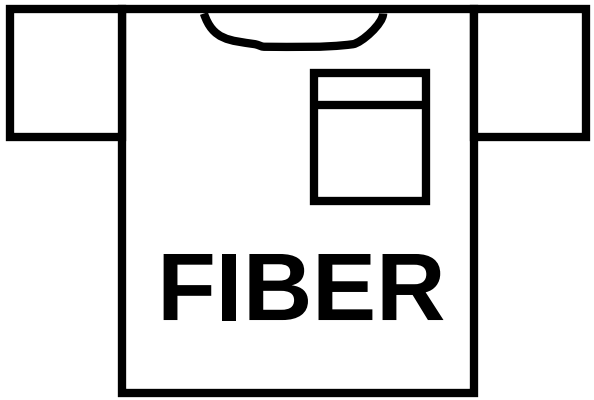
$C_6H_{12}O_6$

a very important compound!!!



FOOD



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Fuels are made from the seeds of some crops, these are known as BIOFUELS

Brassica rapa **= rapeseed oil =CANOLA OIL**

CANOLA OIL can be used to make biodiesel

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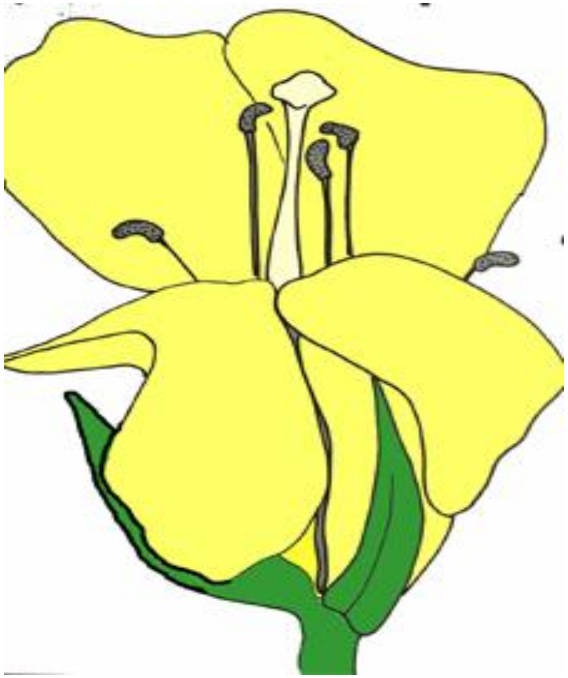
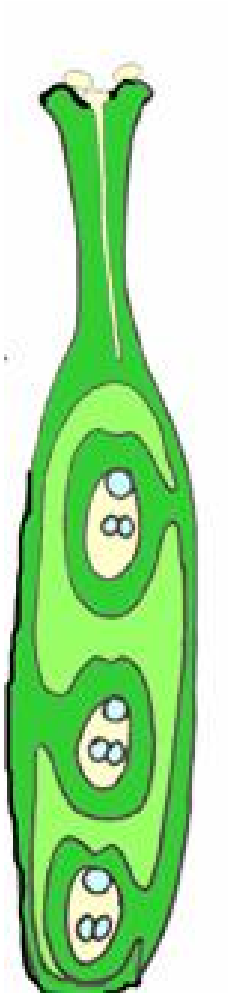
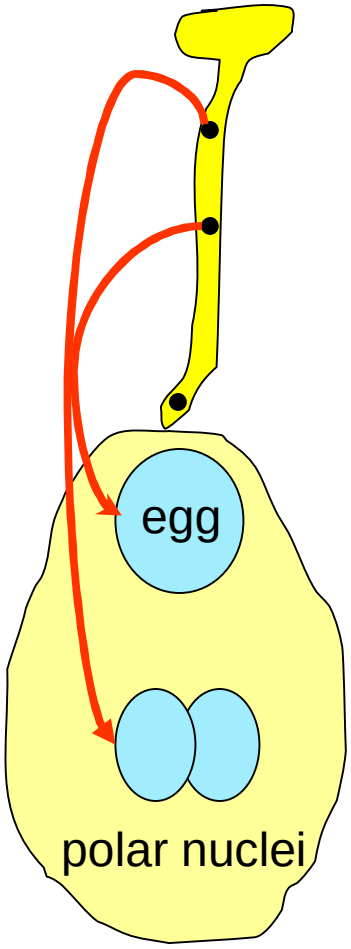
How does the oil get into the seed? First…. fertilization occurs







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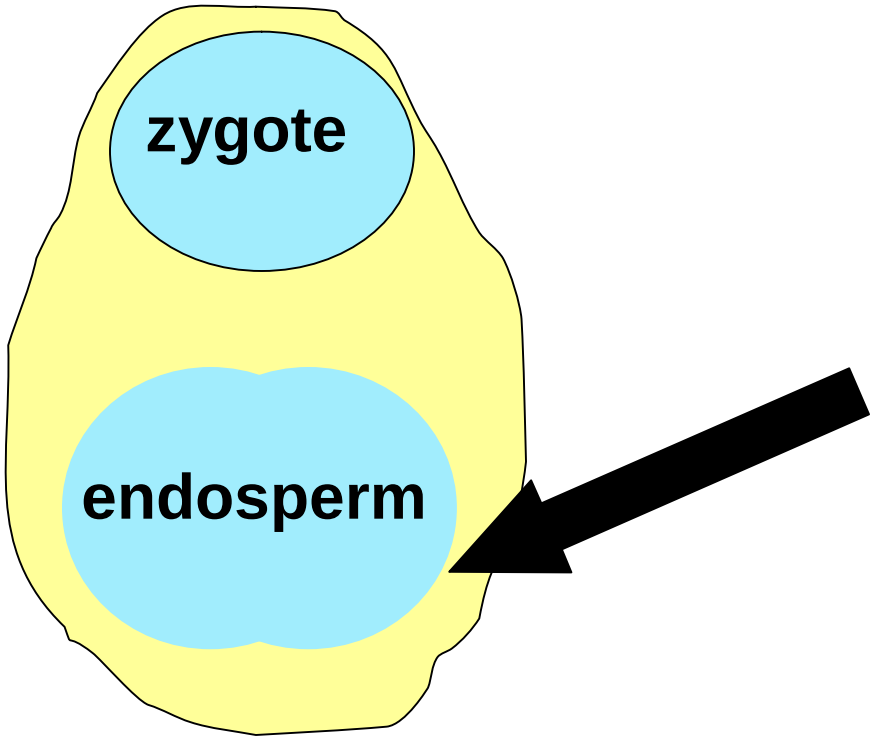
The zygote develops into an embryo by mitosis



$C_6H_{12}O_6$

The endosperm produces starch using the products of photosynthesis

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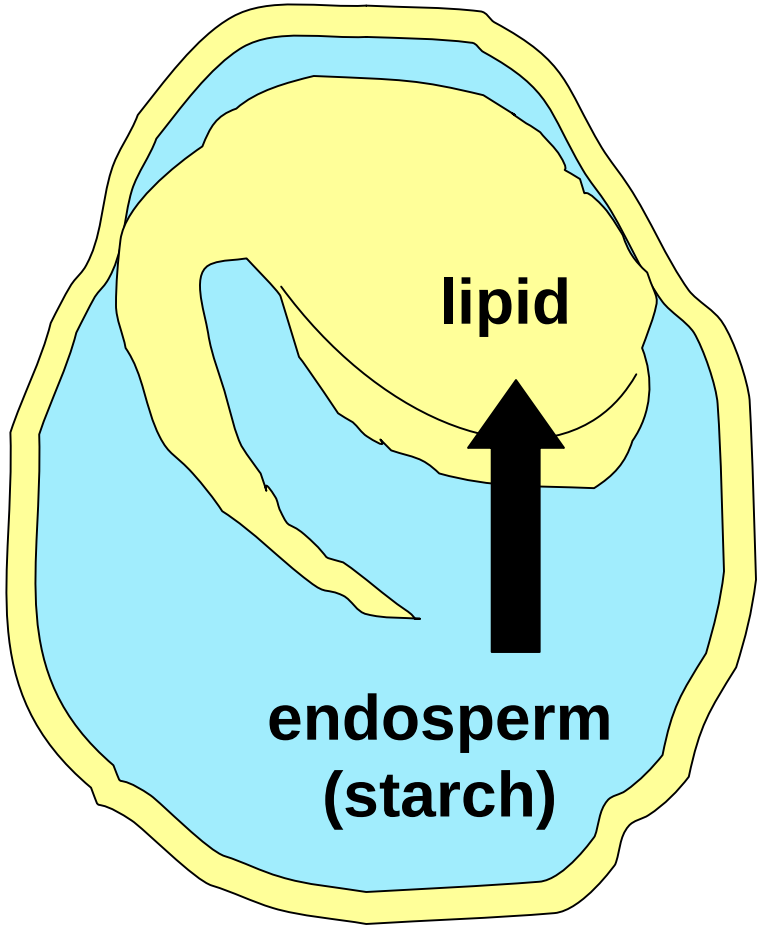
The starch from the endosperm is converted into lipid



The lipid is stored in the cells of the embryo for later use during germination

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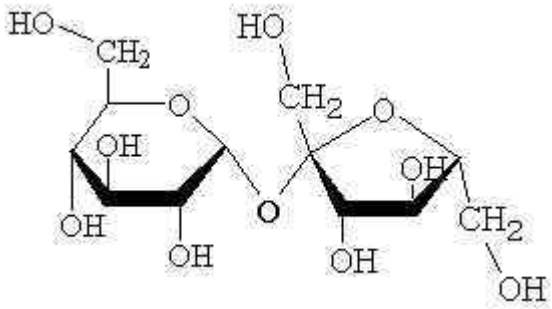
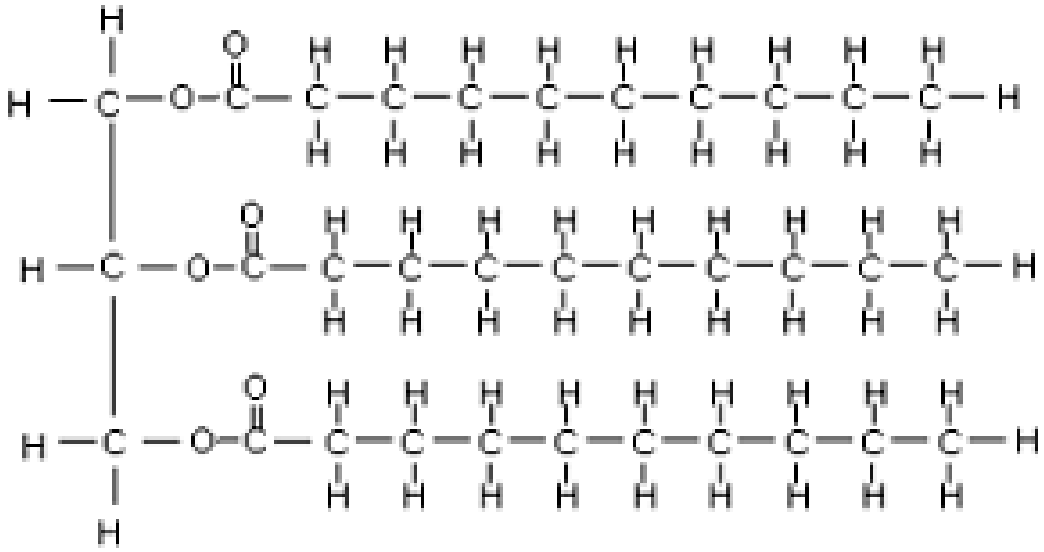
Why are lipids so useful?



SUCROSE

As we've learned so far, plants use photosynthesis to make sugar which is converted into starch. This is an example of sucrose…notice what a big clunky molecule this is?



Triglycéride

On the other hand, fats, made of triglycerides (see image on left), contain a lot more chemical energy (almost 2X as much) and they are so elegantly arranged and take up less space in the cell

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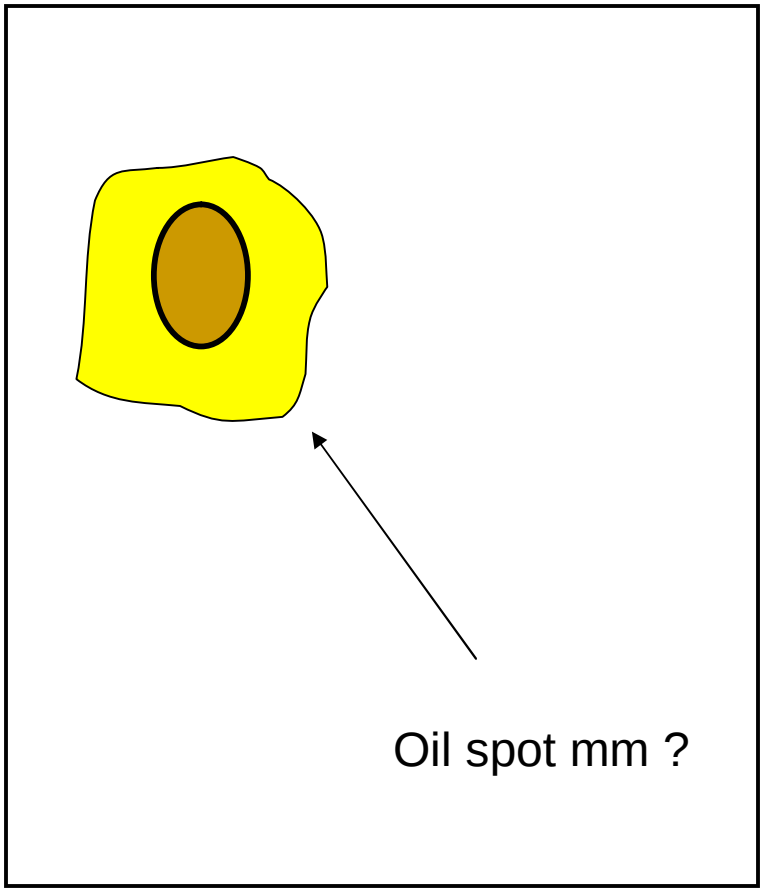
How much oil is in a Fast Plant seed?



Tape a seed to filter paper using regular old scotch tape

Smash seed onto filter paper
And measure the diameter of the oil spot that the seed create on the other side of the filter paper.

Trace the oil spot diameter right away because the oil spot will fade away over time

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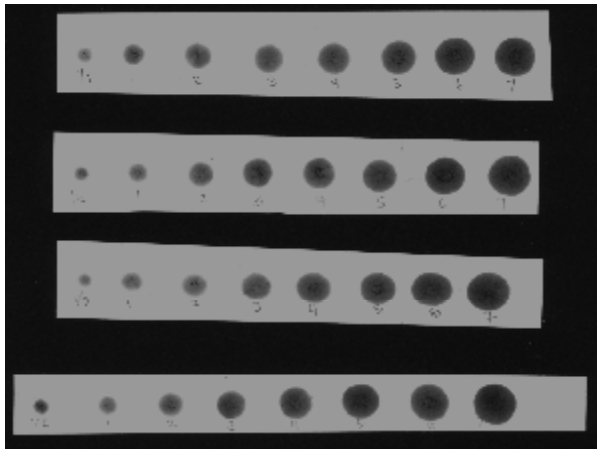
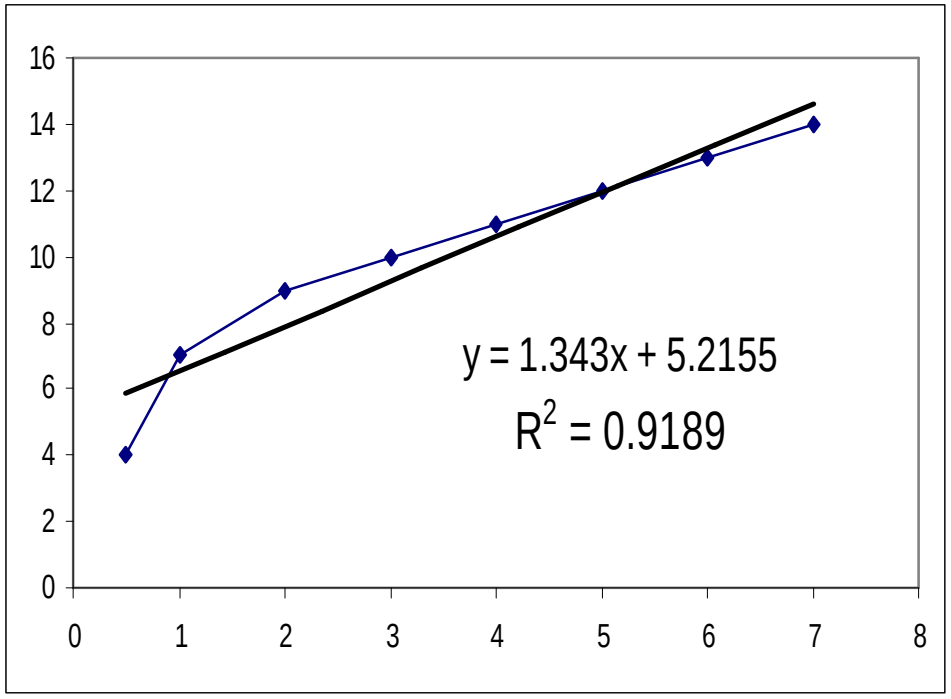
How much oil is in a Fast Plant seed?



Using a standard set of known volumes of oil spotted onto filter paper, create a graph of volume vs. diameter



Then using the equation generated from the plot, calculate the volume of oil in a single Fast Plants seed?

X= (5.2155-y)/1.343

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How much oil is in a Fast Plant seed?

INQUIRY:

- How many Fast Plant seeds would it take to get 1 liter of oil?
- How many seeds does a plant produce?
- How many plants would it take to get 1 L of oil?
- Are there ways to increase the number of seeds?
- Are there ways to increase oil yield?

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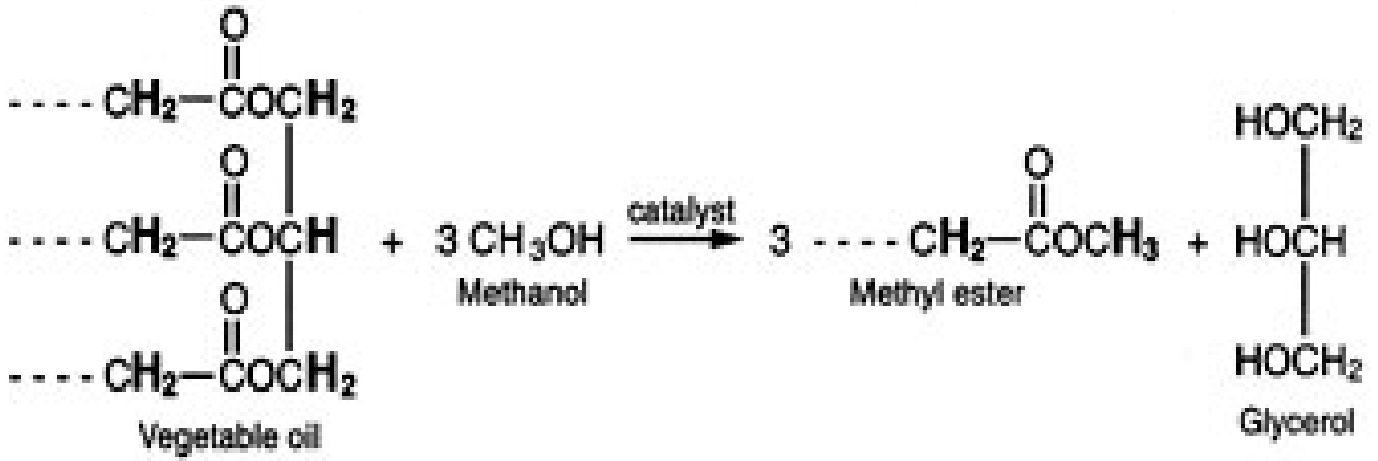
How to make biodiesel from seed oil?

Oil + MeOH + KOH à BIODIESEL + glycerol



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Recipe for biodiesel

OIL: 500 mL

Methanol (20%-25%)*: 100-125mL

KOH (or NaOH)**: 3.0g (or 2.0g)

****Using different catalysts results in different glycerol (waste) layer. It is commonly assumed that using KOH produces a biodegradable waste while NaOH will not. This is another point for inquiry based experimentation using bottle biology (see below)**

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Recipe for biodiesel, cont'd

First, mix MeOH and KOH VERY VERY CAREFULLY
(wear gloves and eye protection!!!)

It takes some time for the KOH/NaOH to dissolve in the MeOH. This step can be done the day before to save time.

Next, divide the 500 mLs oil into smaller volumes
(100mL per reaction vessel)

Preheat the oil by placing it into hot water (boil water in large bowl in microwave and put the reaction vessel containing oil in it to warm up). The reaction occurs faster if the oil is warm. Caution: the flash point for MeOH is 148F, so make sure that the oil is warm, but not too warm.

Add the "methoxide" (MeOH+KOH) to the oil
(20-25 mL per reaction vessel)

Mix the biodiesel reaction by agitation for 5-10 minutes by hand. Alternatively, a blender can be used (with caution) to speed up the reaction.

Allow biodiesel to rest overnight. This step allows the glycerol to separate out from the biodiesel. The biodiesel will be cloudy (it takes a couple of days for the biodiesel to clear up, but have faith, it WILL clear up).

Observe how the biodiesel separates into two phases (the glycerol layer will be on the bottom).

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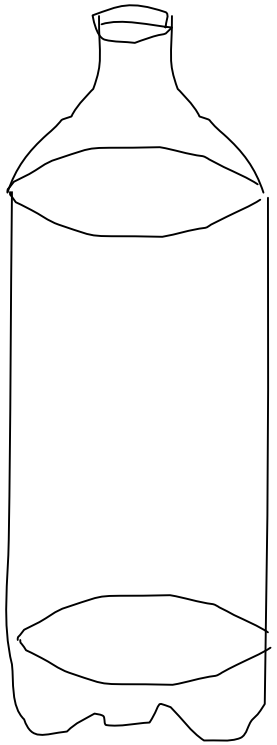

← Fill line (1/5 total volume of vessel)

BIODIESEL REACTION VESSEL (empty soda bottle)

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Biodiesel

- Renewable
- Clean burning
- Relatively easy to produce
- Byproducts are biodegradable

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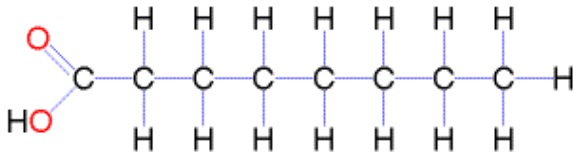
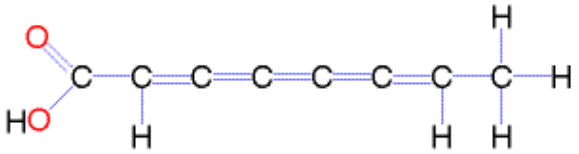
TITRATION

If you are going to try to use waste vegetable oil (WVO), then you will have to titrate the oil to determine how much more catalyst (KOH, NaOH) to add to the reaction in order to neutralize the free fatty acids that formed when the oil was used for cooking.



Saturated



Unsaturated

<u>Materials</u>:

Methanol (10mL)

titration solution (1 g/L NaOH or KOH in water)

1 mL WVO sample

pH indicator (must accurately measure between 7-9) (phenopthalein/phenol red works well)

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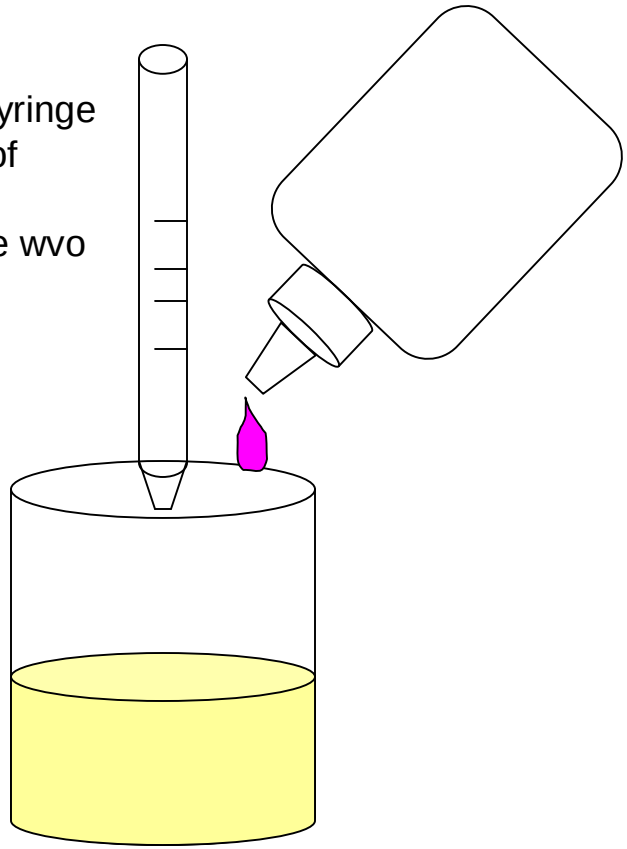
TITRATION, cont'd

A pipette or graduated syringe to measure the volume of titration solution required to neutralize the wvo



Add three drops pH indicator to the 1mL WVO mixed with 10mL MeOH or pure isopropanol (it will turn yellowish)

Small container for titration (jelly jar works well)

http://www.biodieselcommunity.org/recipecalculator/ ß very useful for calculations!

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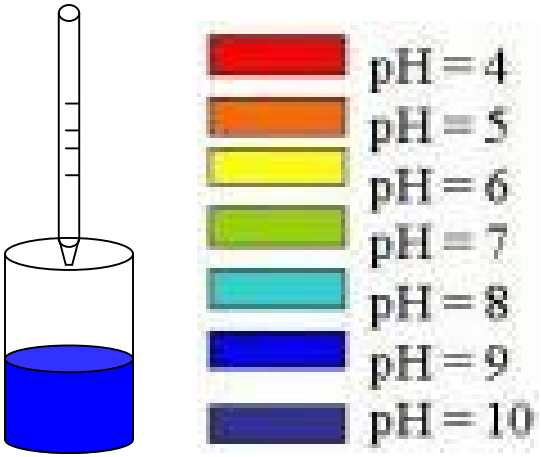
TITRATION, cont'd



Note: this titration was done using the pHydrion titration solution
Other solutions may have different indicators (colors) for each pH value

← Desired pH range

Add titration solution 1mL at a time until the pH of the solution reaches a pH of approximately 8; record the volume (mL) used. This volume corresponds to the number of grams catalyst to add
For example:
It took 5mL to bring the pH of the WVO to a pH of 8-9.

Grams of KOH to add to MeOH to react
1 LITER of WVO:
5 + 6 = 11 grams KOH added to 200 mL MeOH

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COMPOSTING THE GLYCEROL

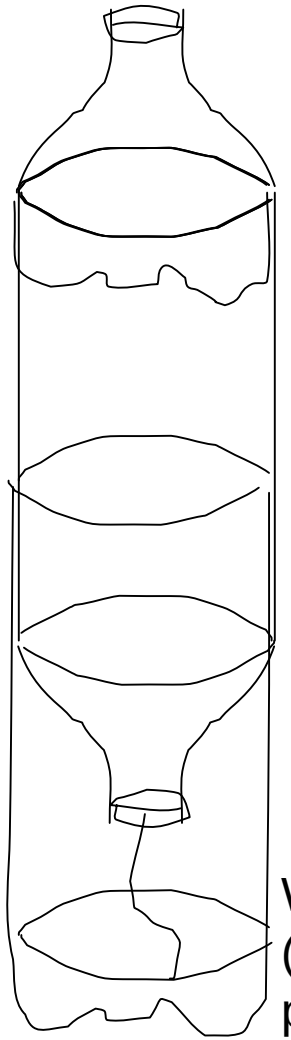
Objective: to determine how long it takes to compost the biodiesel and/or the glycerol waste from biodiesel production and to
assess the impact on soil health (will plants grow?) and water composition (what happens to water pH)

You will need 2-3 two liter bottles for the composter
To the composter, add soil, leaves (green and brown), Food waste, etc…

INQUIRY **à** have students develop their own composting system and see which ones work the best

After biodiesel is made, it can be separated from the glycerol and the biodiesel and/or the glycerol can be added to the composter. What will happen?

What happens to soil if add glycerol made from biodiesel that was made with NaOH, KOH?



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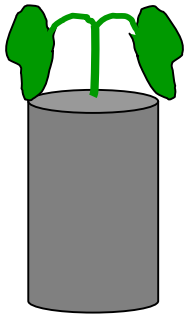
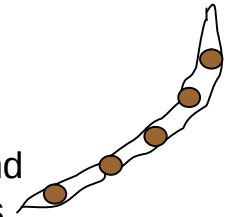
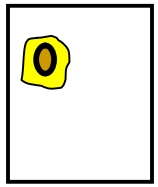
Brassica Biodiesel Curriculum Flowchart



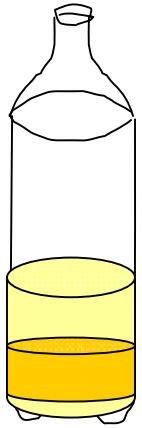
Grow plants and harvest seeds

(28-35 days)



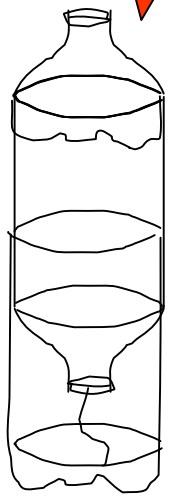


Analyze oil in seeds (1-2 days)



Make biodiesel

(1 day, plus few days settling time)



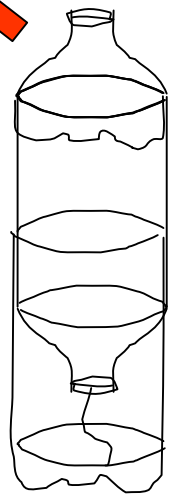
Make biodiesel composter

(1-2 days)

Add glycerol and/or biodiesel

Assess ecological impact in the composter

(time unlimited)



Implement into other inquiry based projects

- Soil/water chemistry
- Effects of pollution on plant health
- Lots of space for more here

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EENC useful webpage resources:

www.fastplants.org (the official fast plants webpage; lots of info and activities ideas)
www.bottlebiology.org (diagrams for building various bottles for use in biodiesel composting experiments)
www.carolina.com (source for materials and lab supplies)
http://www.biodieselcommunity.org/
(a really great biodiesel page with a lot of useful info and pictures)
www.journeytoforever.org (biodiesel webpage with tons of information)
www.localb100.com (another biodiesel page with lots of information)
www.cubiodiesel.org (click on the "project yellow bus" for K-5 curriculum)
www.biofuels.coop (a NC biofuel coop; education information, etc)
http://www.rohmhaas.com/company/plabs.dir/exp09.htm (a site for soapmaking in the classroom; can be used in conjunction with biodiesel for a comparing/contrasting soapmaking with biofuels production process)
http://www.forestry-suppliers.com/s01_pages/lessonplan_htmpages/912_soilph.asp
(a lesson plan for checking soil pH, can be used with composter unit)

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Rationale for biodiesel curriculum

It is important for students to realize the interconnectedness of our activities to the natural world (both positive and negative). Discussing biodiesel in the classroom brings about the possibility for further discussion about the history of our fossil fuel use and what it has done and why. Such discussion will help students to also learn how science is intimately related to other topics like economics, politics, ethics, etc.

Biodiesel education also creates an opportunity for students to appreciate the interconnectedness of many scientific disciplines. Biology gives us the plants that make the oilseed (or algae or whatever). Chemistry helps us to explain the process of transesterfication. Physics helps us to explain how the phases separate and how certain molecules are more combustible than others. Physics is also important when considering that without the sun and photosynthesis, no carbon would be fixed and no oil would be synthesized.

Biodiesel education also gives students a feeling of empowerment. By this I mean that the students can see how they themselves can directly impact the environment by making certain choices (to drive a diesel powered car). Also, the fact that biodiesel can be made very simply makes it easier for students to interact with the process. Introducing a biodiesel curriculum to high school and college level courses could have a significant impact on their choices as consumers, etc. Further, one could imagine that an integrated biodiesel curriculum would reach out to students who would otherwise be turned away from science in general. The word, “integrated” is used here to include the plant portion of the unit, so that students see a direct connection to the environment.

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