Organic Molecules
Functional Groups

Lipids:
terpenes, fats, oils, waxes, steroids

Dr. Ron Rusay

Lipids: Fats & Oils

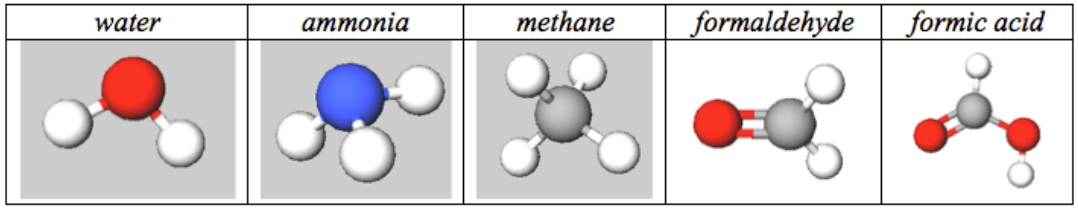
Lipids are natural plant & animal products more soluble in non-polar solvents like gasoline than in water.

Combustion (burning) of one gram: of carbohydrate produces 4 to 5 Calories, protein produces 4 to 5 Calories, **fat produces 9 to 10 Calories — more than twice that of either sugars or proteins.**

Lipids

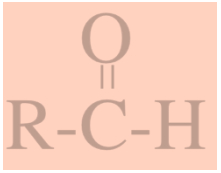
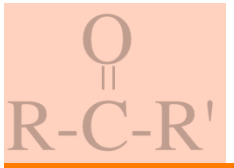
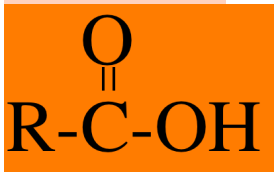
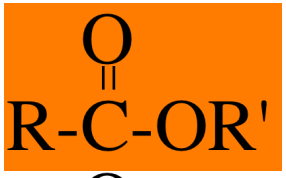
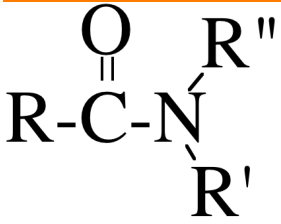
Common Functional Groups

Name	General Formula
Alcohols	R−OH (R is very large, note: glycerol is not a lipid)
Ethers	R−O−R′
Amines	$R-NH_2$
Carboxylic Acids	 (R is very large)



Lipids

Common Functional Groups

Name	General Formula
Aldehydes	
Ketones	
Carboxylic Acids	 (R is very large)
Esters	 (R is very large)
Amides	

Lipid Wordsearch

Terry L. Helser
Department of Chemistry, SUNY College at Oneonta, Oneonta, NY 13820-4015; helsertl@oneonta.edu

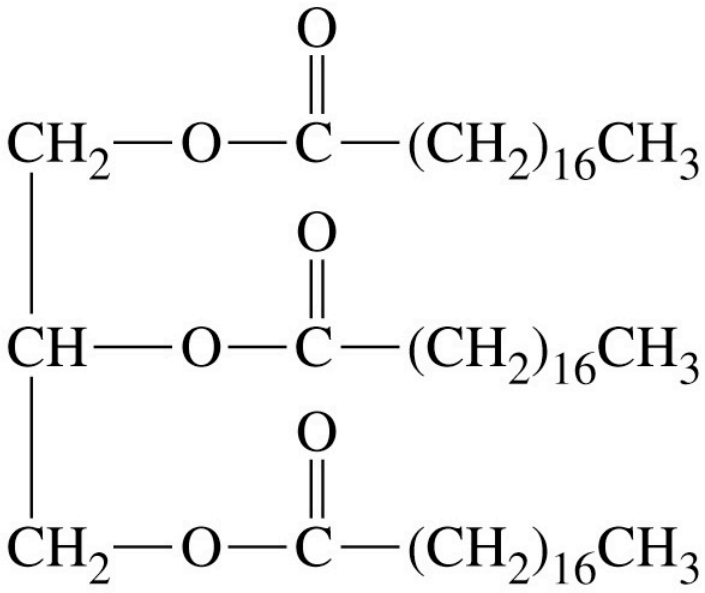
This puzzle contains 37 names, terms, prefixes and acronyms that describe lipids. They may be in any linear direction. Find and highlight these terms in the matrix below. "TRIACYLGLYCEROL" is already done for you. Then, correctly transfer them to the blanks in the description below the matrix. Use the letters remaining in the matrix to complete the sentence describing these molecules. Your success will be rewarded. The answers to the Lipid Wordsearch are found below. Good hunting!

```
N F A T T Y L A I T N E S S E S L
I P O R E T S E A C I D P T T D A
D A C Y L F A T X T I H A S A I N
N O L Y T E C A I P I N S N E P O
A S T P H E W E I N E B F A L I L
L T R I A C Y L G L Y C E R O L I
G E S U E L O O O X I D A T I O N
A R T O L H M N L S T E A R A T E
T O E L P Y I I F M O S A I C I F
S L R S E L P L T Y F I N O P A S
O P O L Y I U N S A T U R A T E D
R H I E D I L O R E T S E L O H C
P N D S D T E R P E N E R P O S I
```

TRIACYLGLYCEROLs are E____s of P_________,
S_______, and O_____ with glycerol. S_______ them
to make S___. B___ O_________ cleaves their ____-
C__ s into A_ _ _ _ _ _-_ _ _ _s. The E_ _ _ _ _ _ _ _ F_ _ _ _
A___s include _________ and ______N___, which
are P___U__________ with 2 or 3 C__ double bonds.
They are precursors for P_____________ hormones and
maintain F_ _ _ _ M_ _ _ _ _ membranes as part of
P_____________ and S_____M_____. Hydrogenating
such L_____ makes O___, which can contain T____
double bonds. L_____ is a W__. Polymers of I_____
form the T_____s and other simple L_____ like the
S_____, C_____, and _____D hormones.
Use the remaining 16 letters to fill in the following sentence:
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ for _ _ _ _ .

Molecular Formula: $C_{57}H_{110}O_6$
Molecular weight: 891.4797

Examples of complex lipids

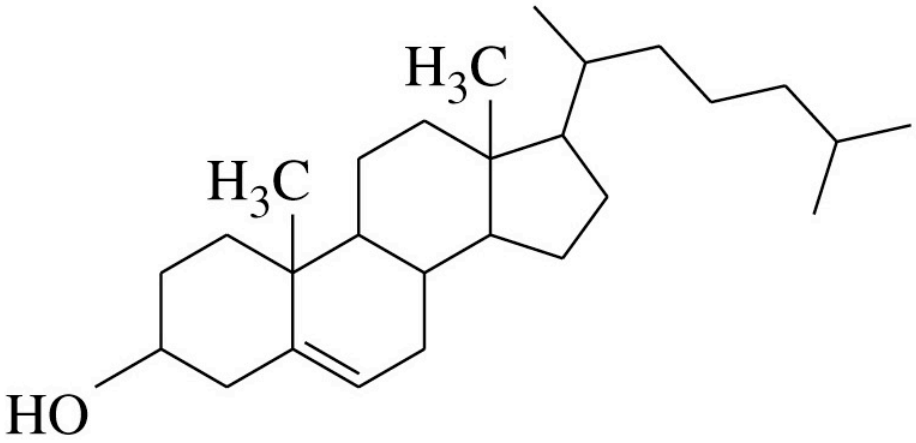


tristearin, a fat

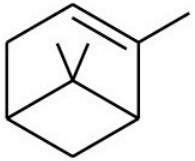
$\Delta_c H°_{solid}$	-35806.7 ± 1.8

kJ/mol

Examples of simple lipids



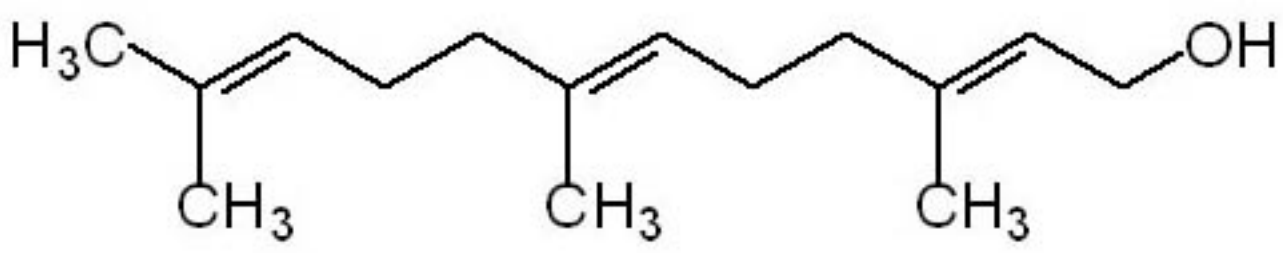
cholesterol, a steroid



α-pinene, a terpene

Question

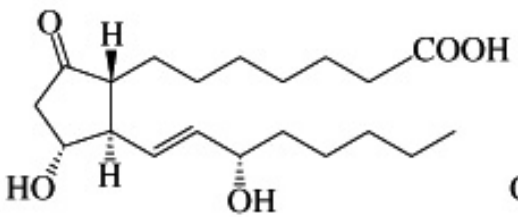
- Farnesol is a lipid that is classified as a



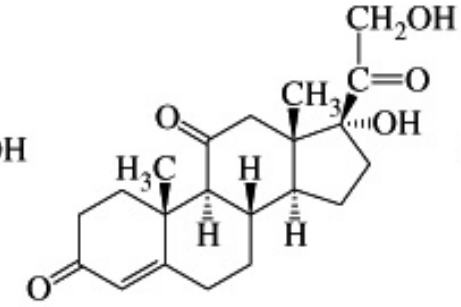
Farnesol

- A) C_{10}, monoterpene, aldehyde.
- B) C_{15}, sesquiterpene, aldehyde.
- C) C_{10}, monoterpene, alcohol.
- D) C_{15}, sesquiterpene, alcohol.

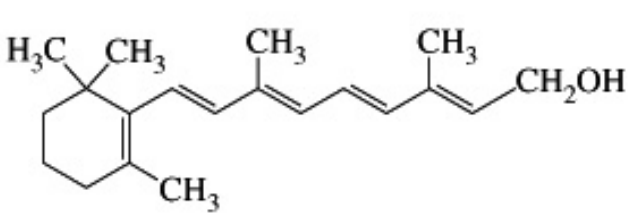
Lipid Examples



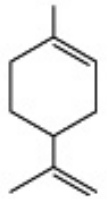
PGE_1
a vasodilator



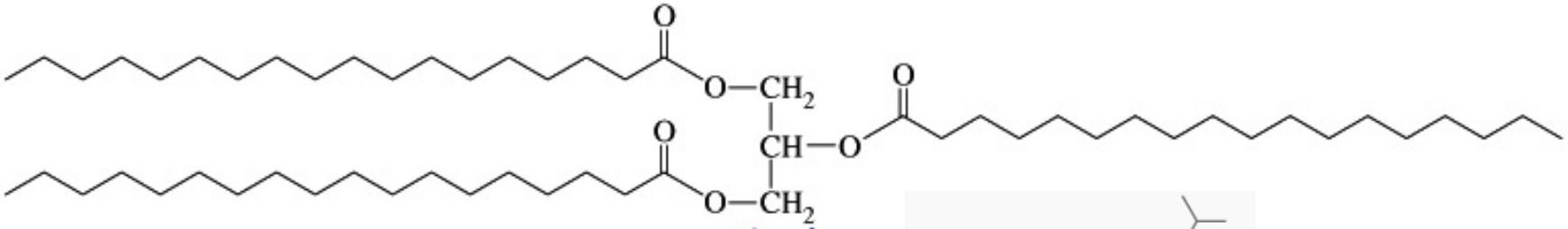
cortisone
a hormone



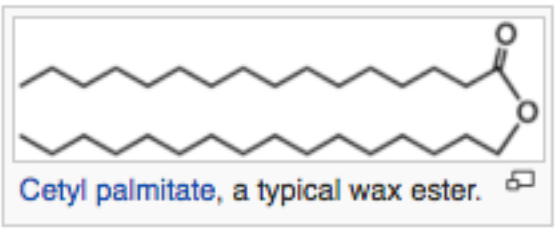
vitamin A
a vitamin



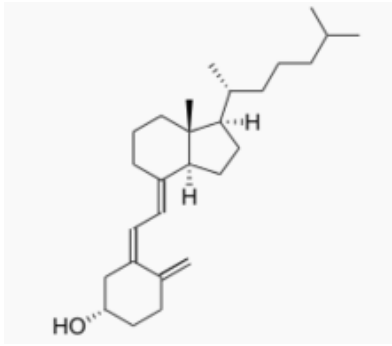
limonene
in orange and
lemon oils



tAearin
a fat



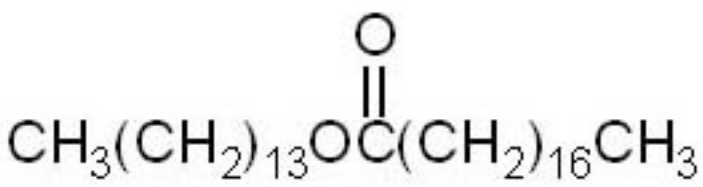
Cetyl palmitate, a typical wax ester.



Vitamin D3

Question

Tetradecyl octanoate is classified as a(n)

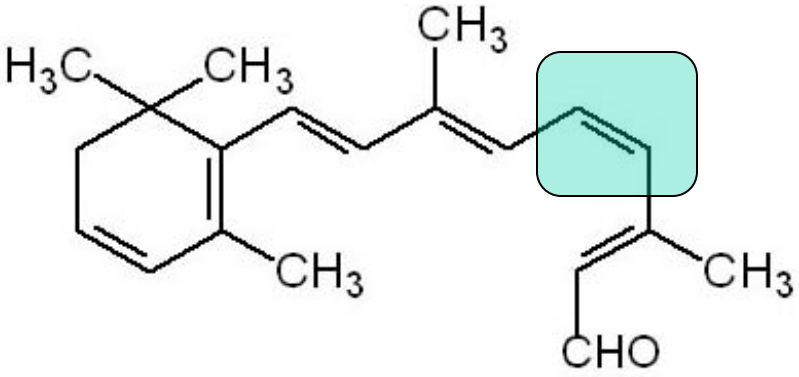


Tetradecyl octadecanoate

- A) ester (wax). B) fatty acid.
- C) ketone (terpene). D) steroid.

Question

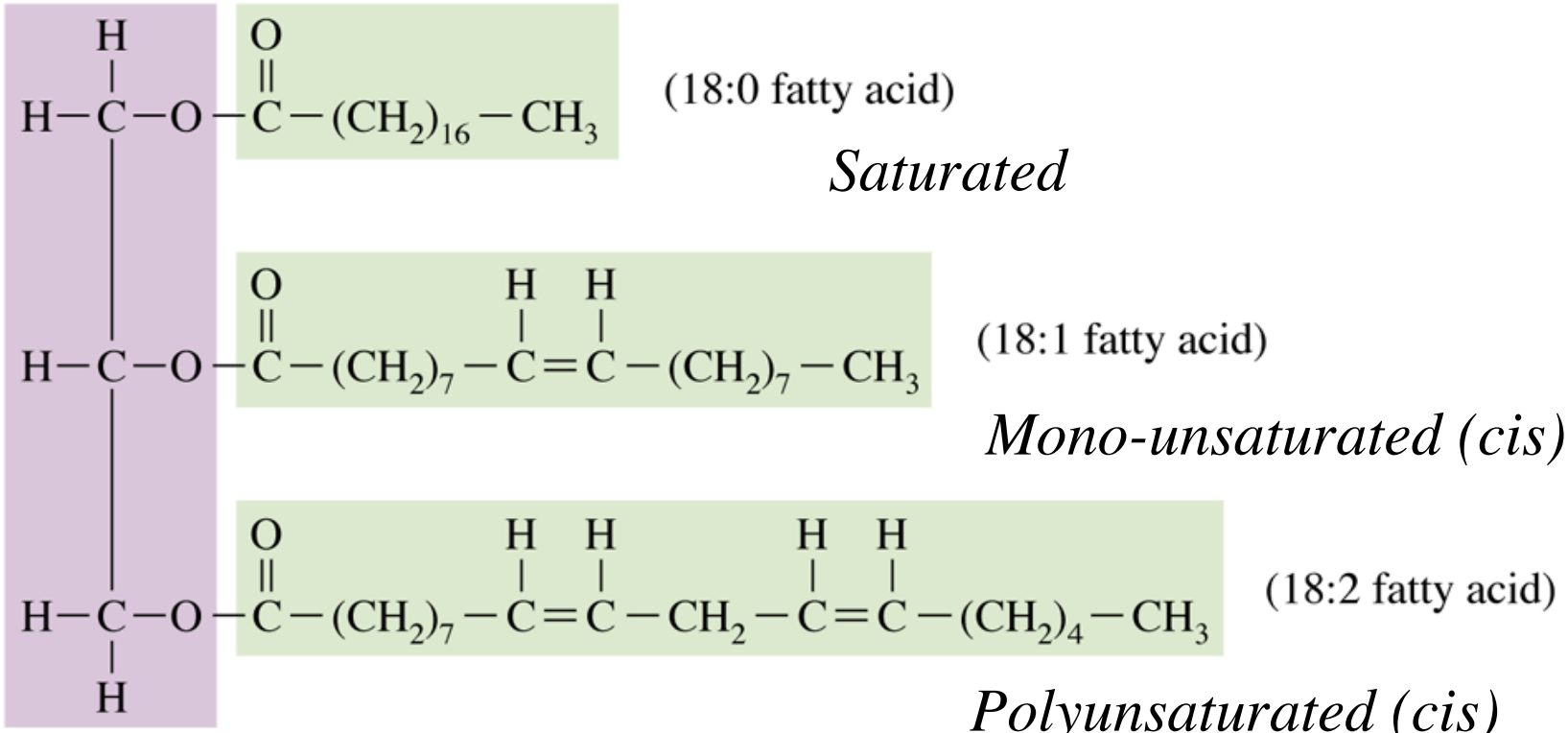
Vitamin A2 binds to opsin. It is a(n) _____ and has an important C=C double bond, which is _____.



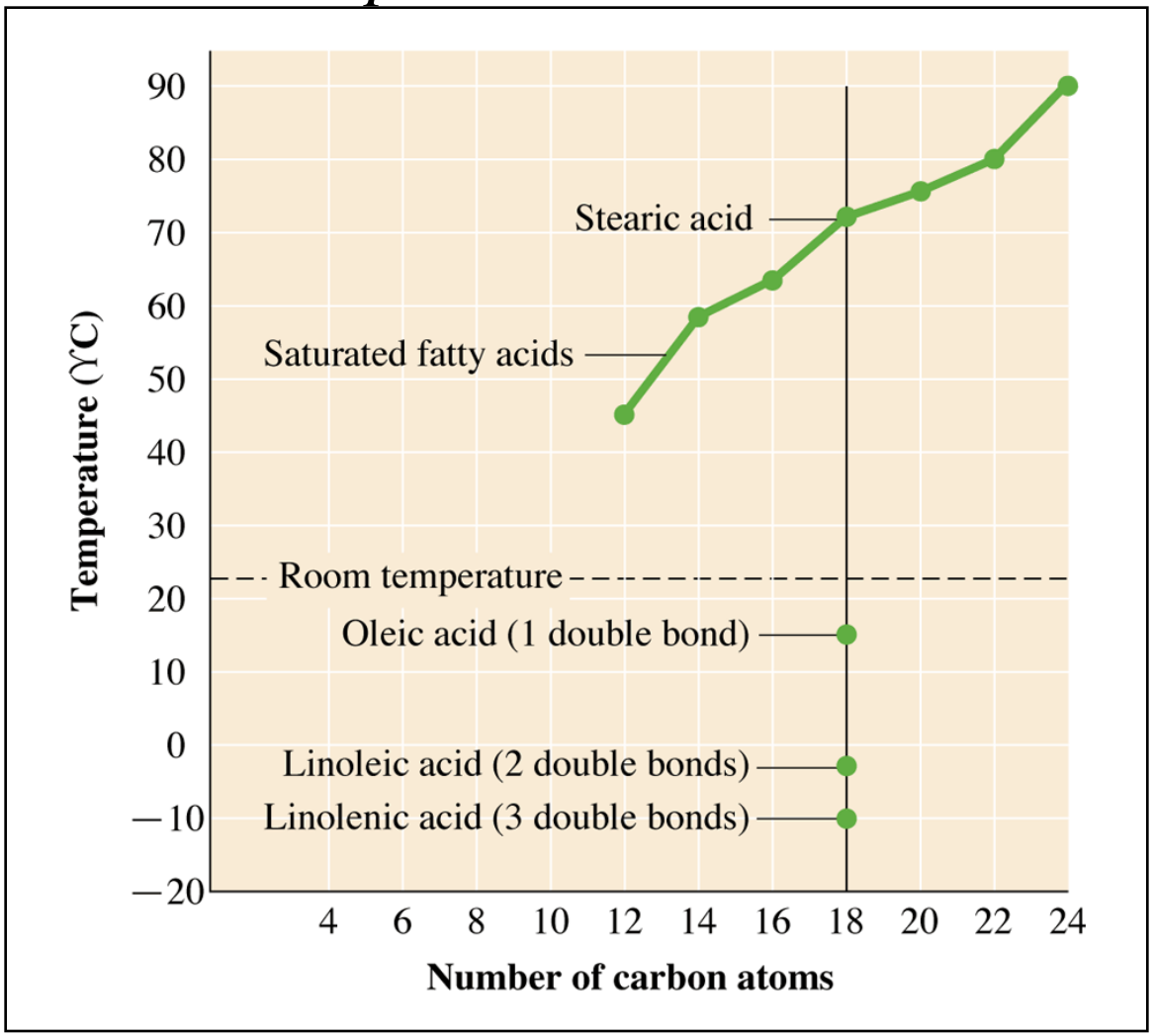
Vitamin A2

- A) alcohol, trans
- B) alcohol, cis
- C) aldehyde, trans
- D) aldehyde, cis

Structure of a mixed triacylglycerol in which three different fatty acid residues are present.



The melting point of a fatty acid depends on the length of the carbon chain and on the number of double bonds present in the carbon chain.



Question

Which of the following statements regarding fatty acids is false?

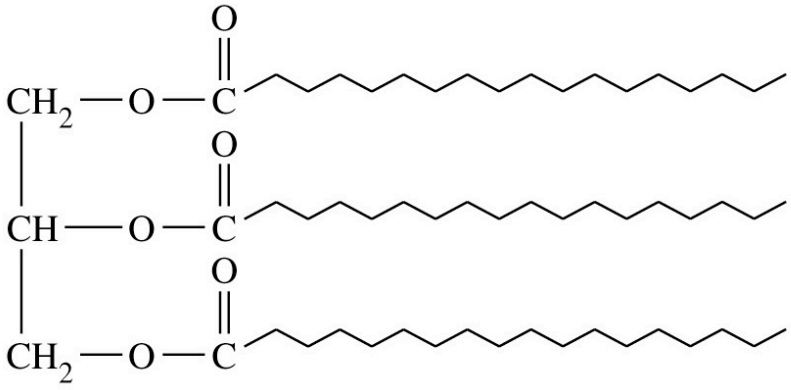
A) Fatty acid can have one or more carbon-carbon double bonds.

B) Naturally occurring fatty acids have an odd number of carbons.

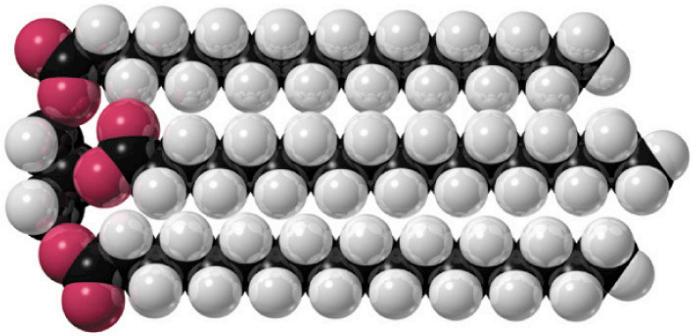
C) The configuration of the double bond(s) is (are) generally *cis* in naturally occurring fatty acids.

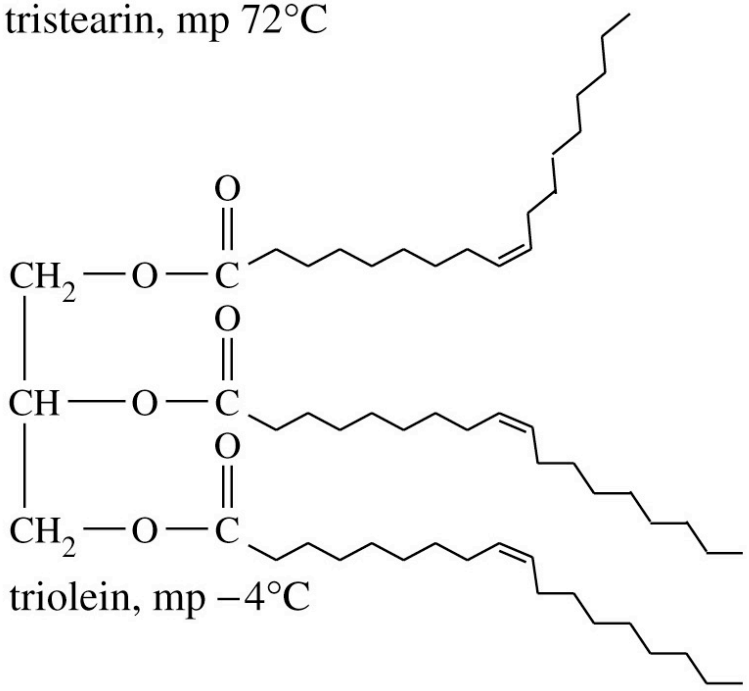
D) Unsaturated fatty acids have a lower melting point than saturated ones.

How do fat molecules differ?

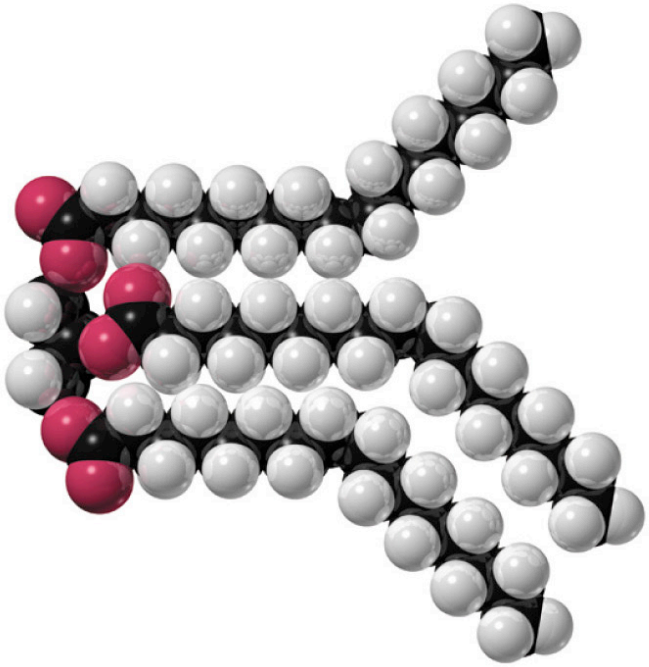


tristearin, mp 72°C

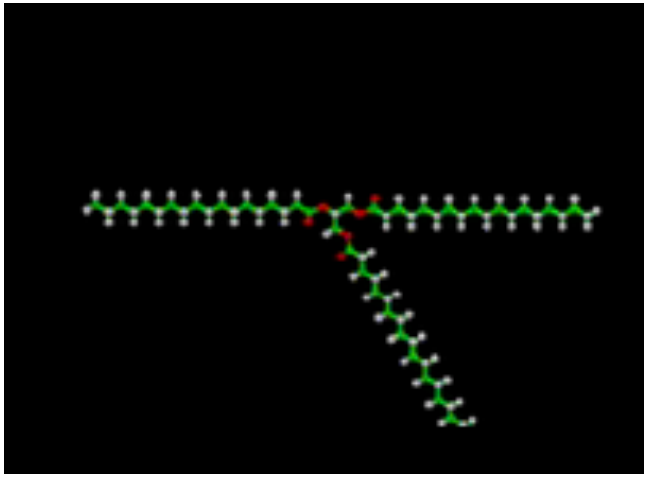


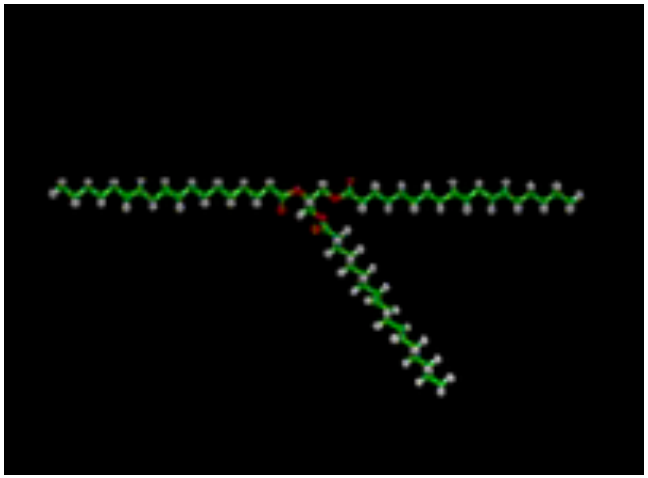


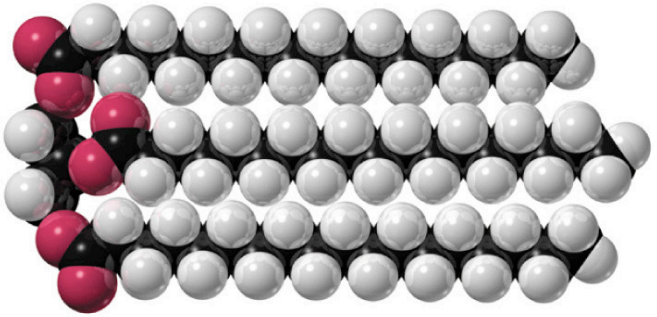
triolein, mp −4°C

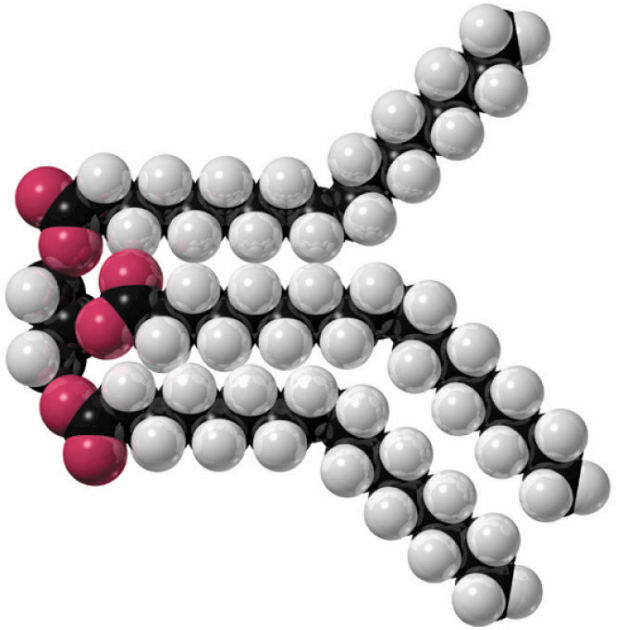


http://chemconnections.org/general/movies/fat-satd.MOV





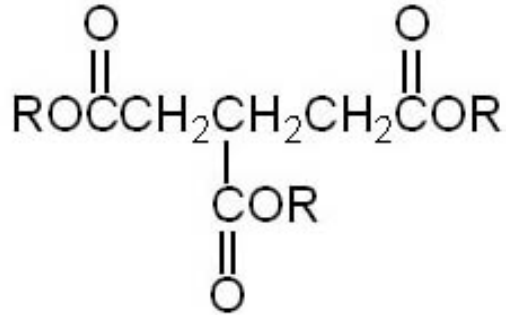


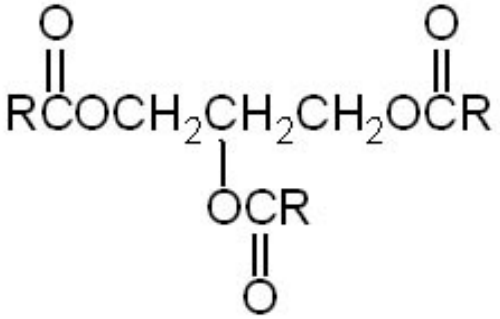


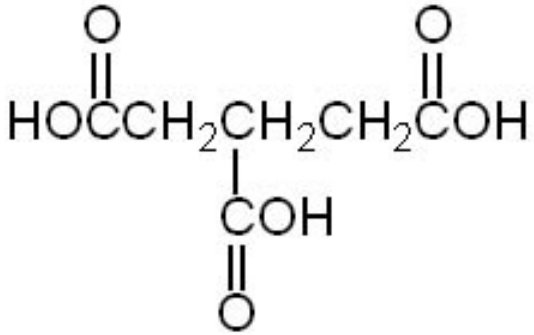
http://chemconnections.org/general/movies/fat-unsatd.MOV

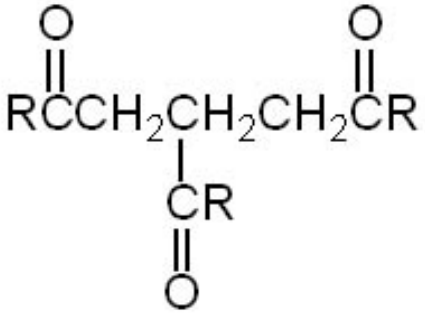
Question

- Which one of the following is a fat, triacylglycerol (triglyceride)?

- A) 

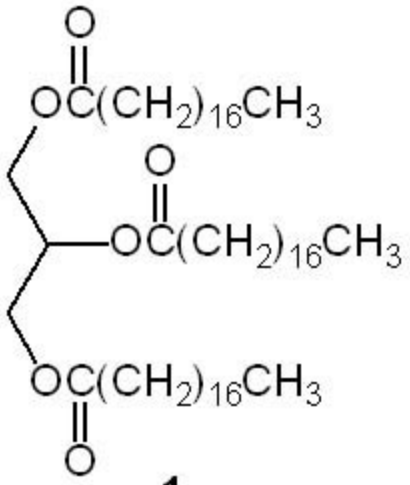
B) 

- C) 

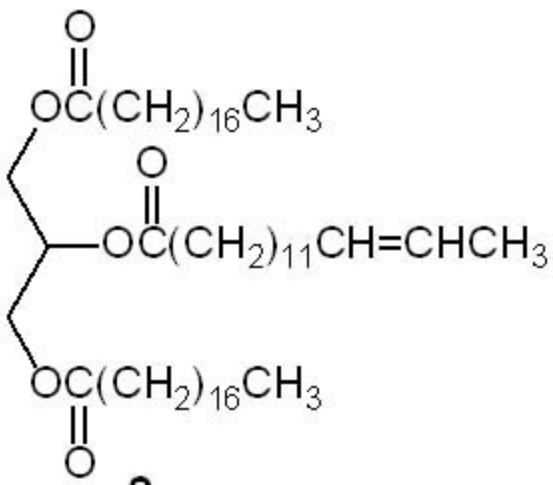
D) 

Question

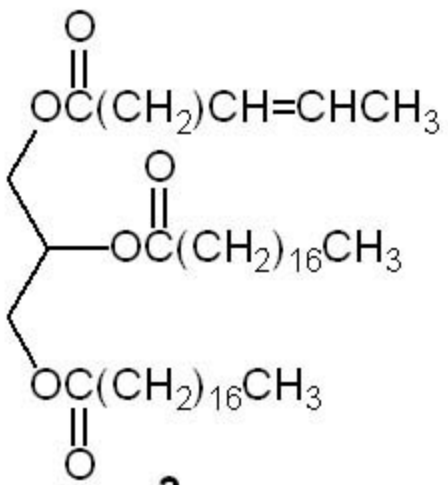
- Which of the triglycerides below is (are) chiral?



1



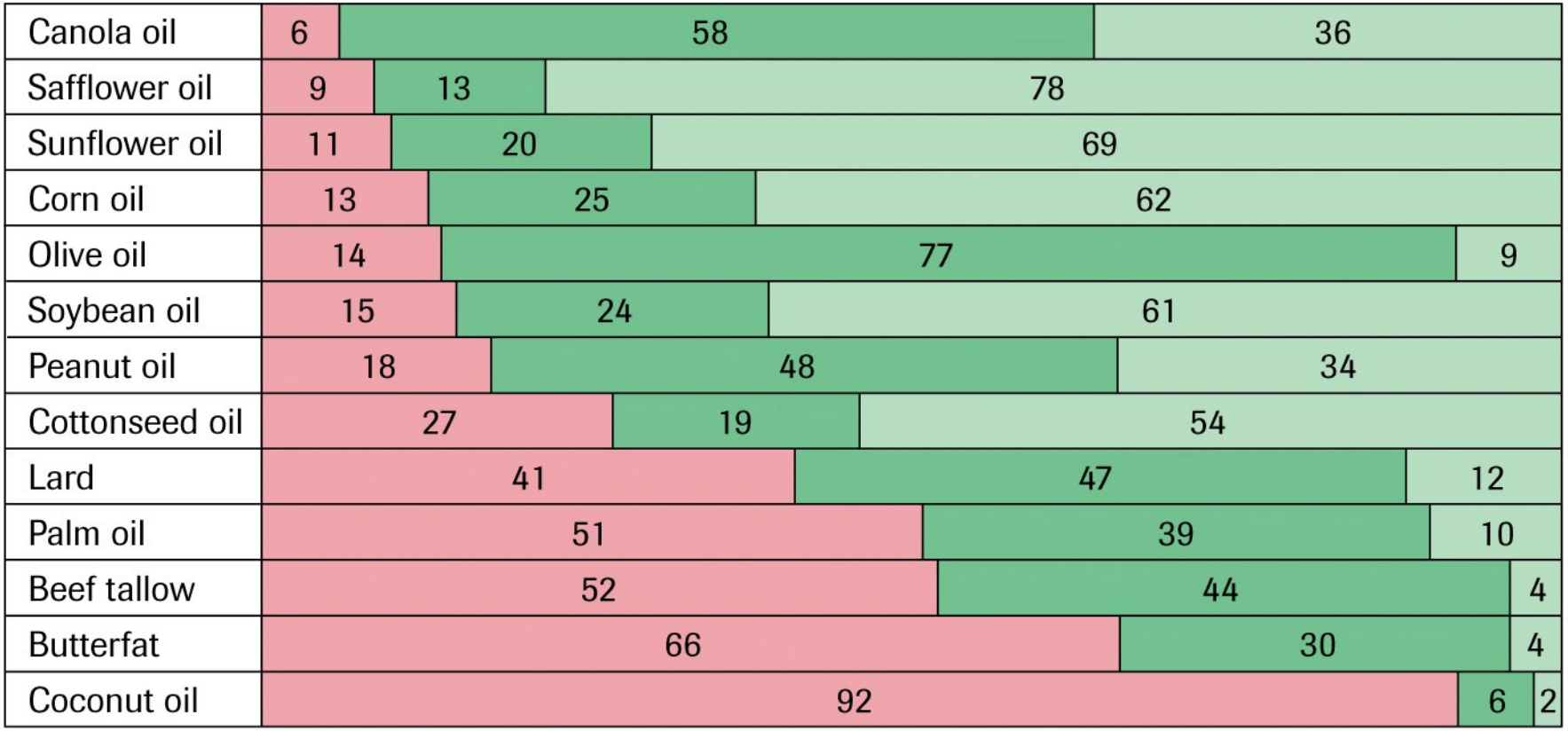
2



3

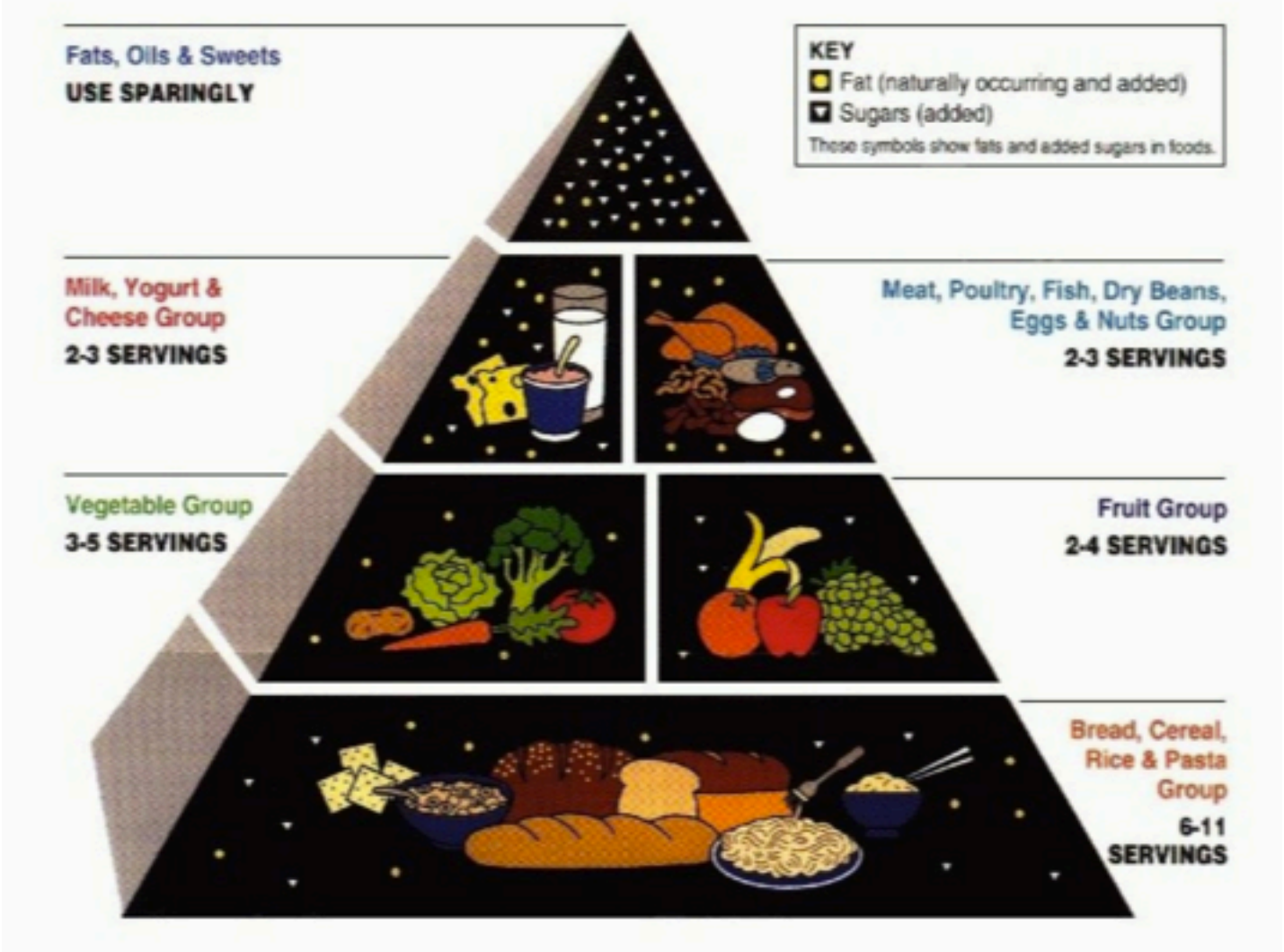
- A) 1 B) 2
- C) 3 D) 2 and 3

Composition of common fats and oils

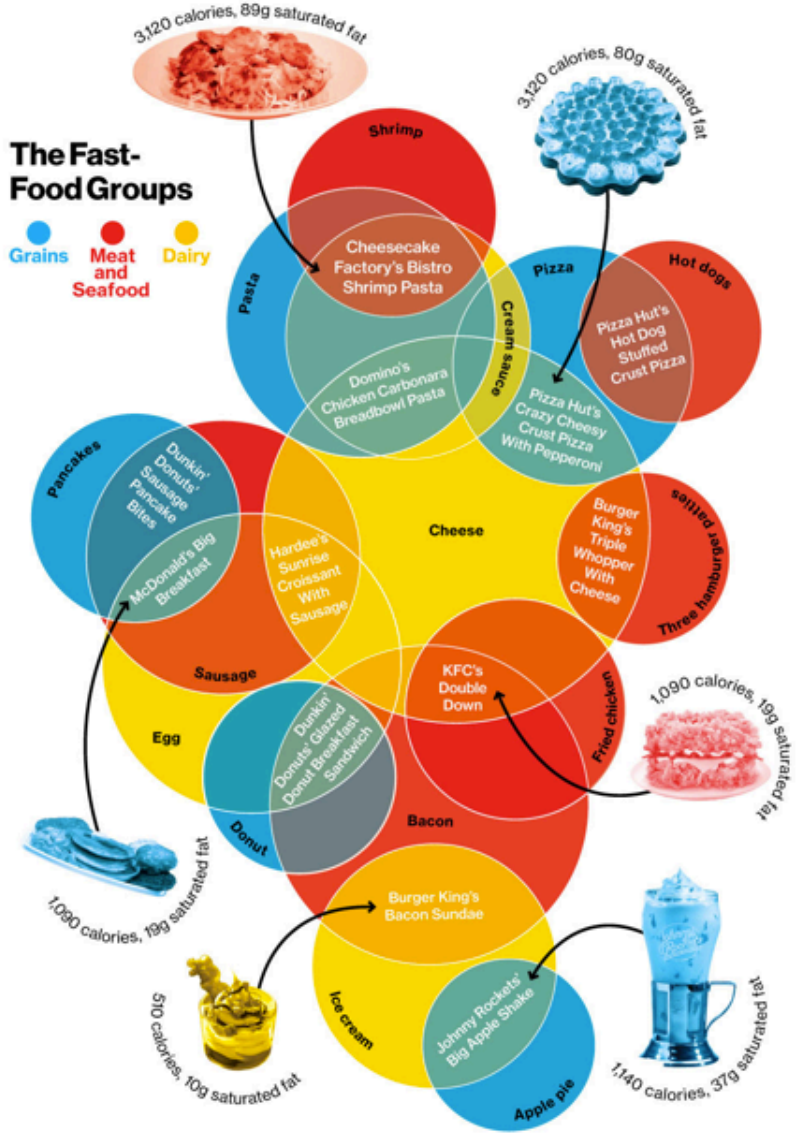


Dietary fat/oil	% Saturated fat	% Monounsaturated fat	% Polyunsaturated fat
Canola oil	6	58	36
Safflower oil	9	13	78
Sunflower oil	11	20	69
Corn oil	13	25	62
Olive oil	14	77	9
Soybean oil	15	24	61
Peanut oil	18	48	34
Cottonseed oil	27	19	54
Lard	41	47	12
Palm oil	51	39	10
Beef tallow	52	44	4
Butterfat	66	30	4
Coconut oil	92	6	2

The collapse of movie theater popcorn sales!



Food Pyramid, April 2016

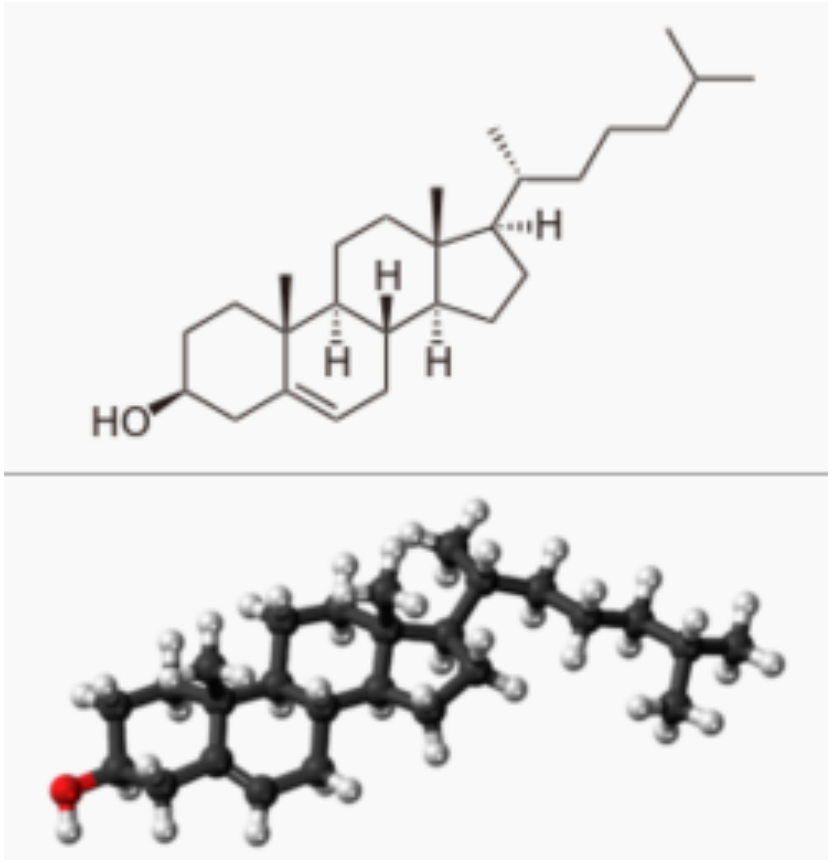


Businessweek, April 2013

The human body is 60-70 percent water, blood is ~90 percent, the brain and muscles are ~75 percent , and bones are ~20 percent by mass. * A human can survive for a month or more without eating food, but only 1-2 weeks without drinking water.

How much energy is required to raise the water in your body from 25°C (average room temperature) to 37°C (average body temperature [that is, chemical -biological temperature])? *Assume that there is the equivalent of 5 liters of water, d = 1.0 g/mL in your body. The heat capacity of water is 4.184 J/g °C (1.00 cal /g °C); (0.001 Cal / g °C); (0.001 kcal /g °C)*

How many grams of fat would need to be burned? *(9 Cal/g)*



- *What is cholesterol?*
- *Is there such a thing as "good" vs. "bad" cholesterol?*
- *How does it relate to fat?*

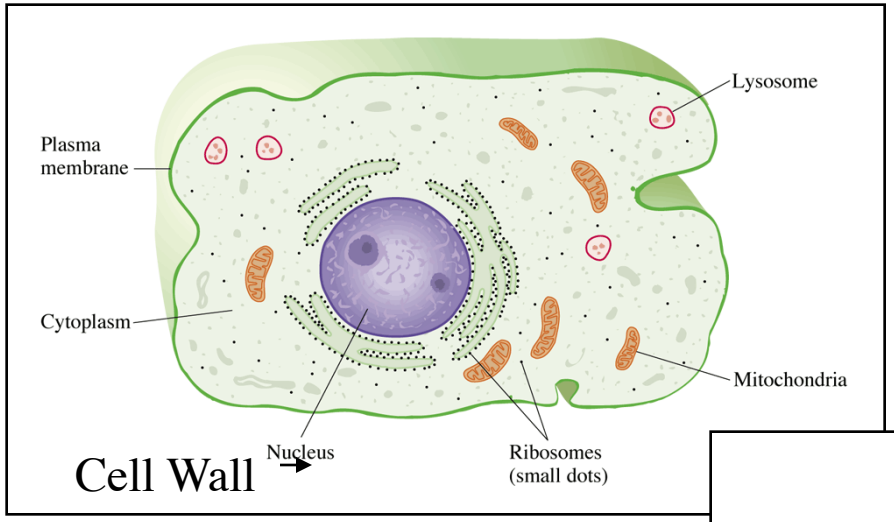
Total Cholesterol Level	Category
Less than 200mg/dL	Desirable
200-239 mg/dL	Borderline high
240mg/dL and above	High

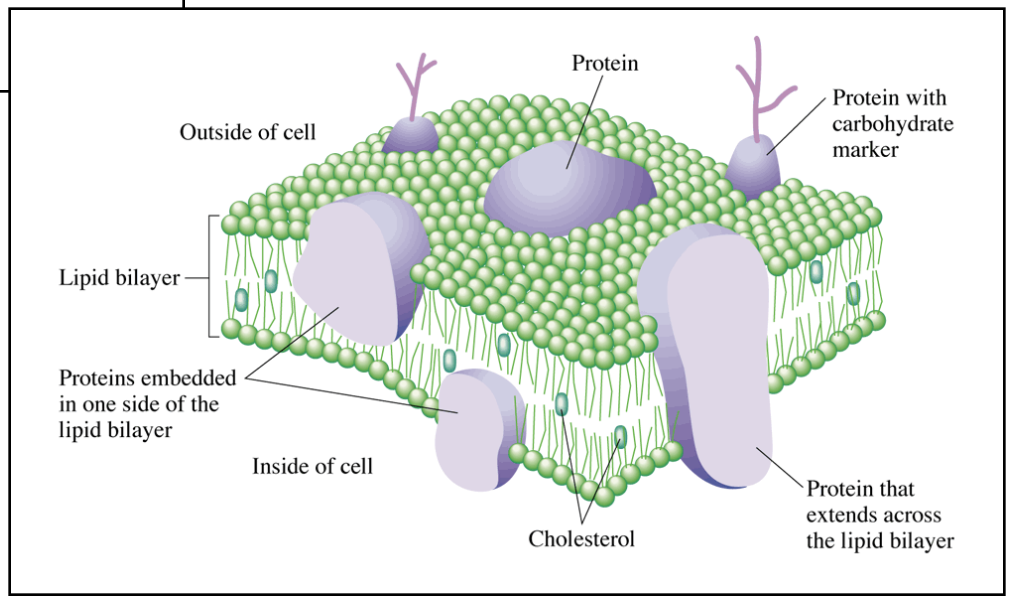
LDL (Bad) Cholesterol Level	LDL Cholesterol Category
Less than 100mg/dL	Optimal
100-129mg/dL	Near optimal/above optimal
130-159 mg/dL	Borderline high
160-189 mg/dL	High
190 mg/dL and above	Very High

HDL (Good) Cholesterol Level	HDL Cholesterol Category
Less than 40 mg/dL	A major risk factor for heart disease
40—59 mg/dL	The higher, the better
60 mg/dL and higher	Considered protective against heart disease

https://www.nlm.nih.gov/medlineplus/magazine/issues/summer12/articles/summer12pg6-7.html

Eukaryotic Cell and Cell Wall

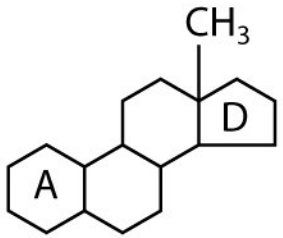




Question

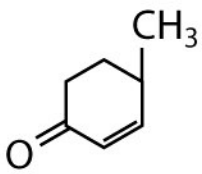
- A major component of a lipid bilayer is
- A) carbohydrate
- B) wax
- C) cholesterol
- D) fat

Steroids

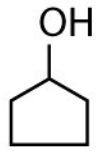


Ring A

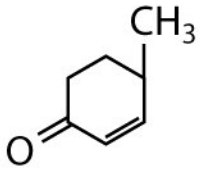
Ring D



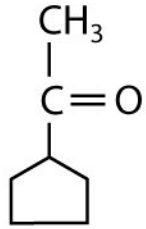
Testosterone

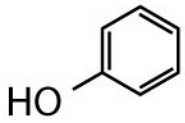


Androsteredione has an = O replacing —OH in ring D of testosterone

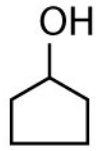


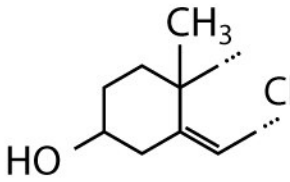
Progesterone





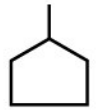
Estradiol





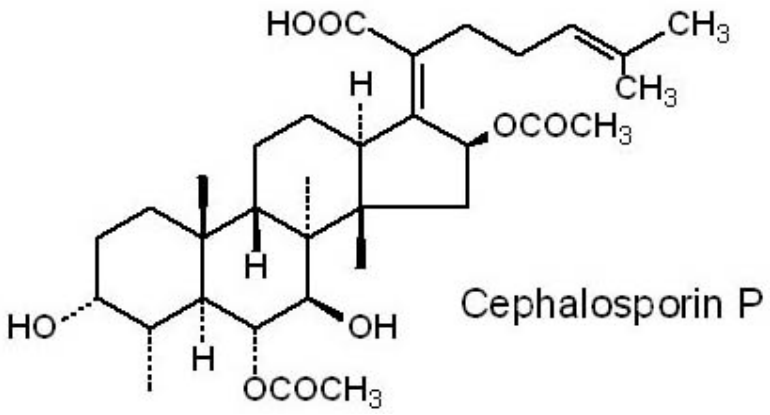
Cholesterol

branched R group



Question

- The backbone structure of cephalosporin P is classified as a

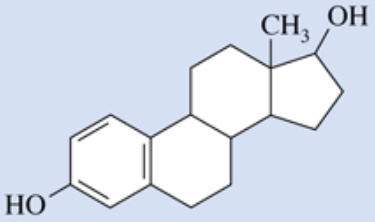


Cephalosporin P

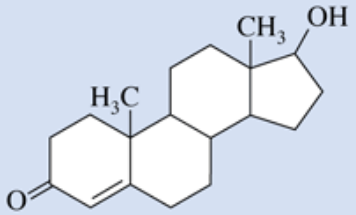
- A) fatty acid.
- B) steroid.
- C) cholesterol.
- D) wax.

Structures of selected steroids. (Sex hormones and synthetic compounds that have similar actions.)

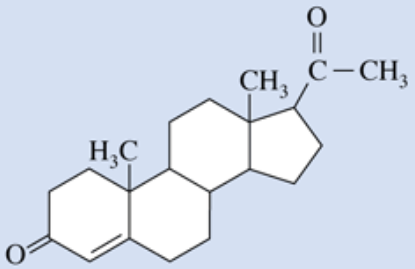
(a) NATURAL HORMONES



Estradiol
(the principal estrogen; responsible for secondary female characteristics)

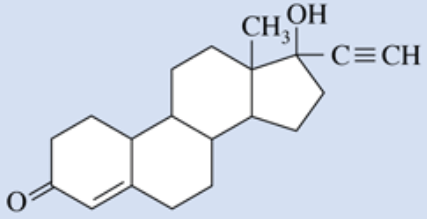


Testosterone
(the principal androgen; responsible for secondary male characteristics)

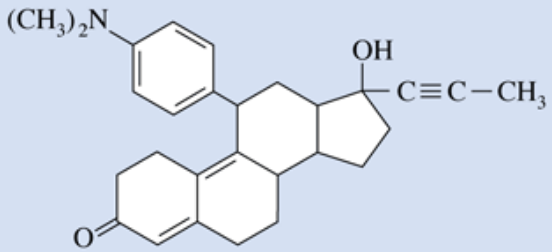


Progesterone
(the principal progestin; prepares the uterus for pregnancy)

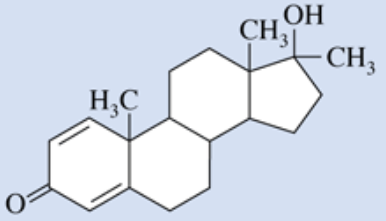
(b) SYNTHETIC STEROIDS



Norethynodrel
(a synthetic progestin)



RU-486
(mifepristone; a synthetic abortion drug)



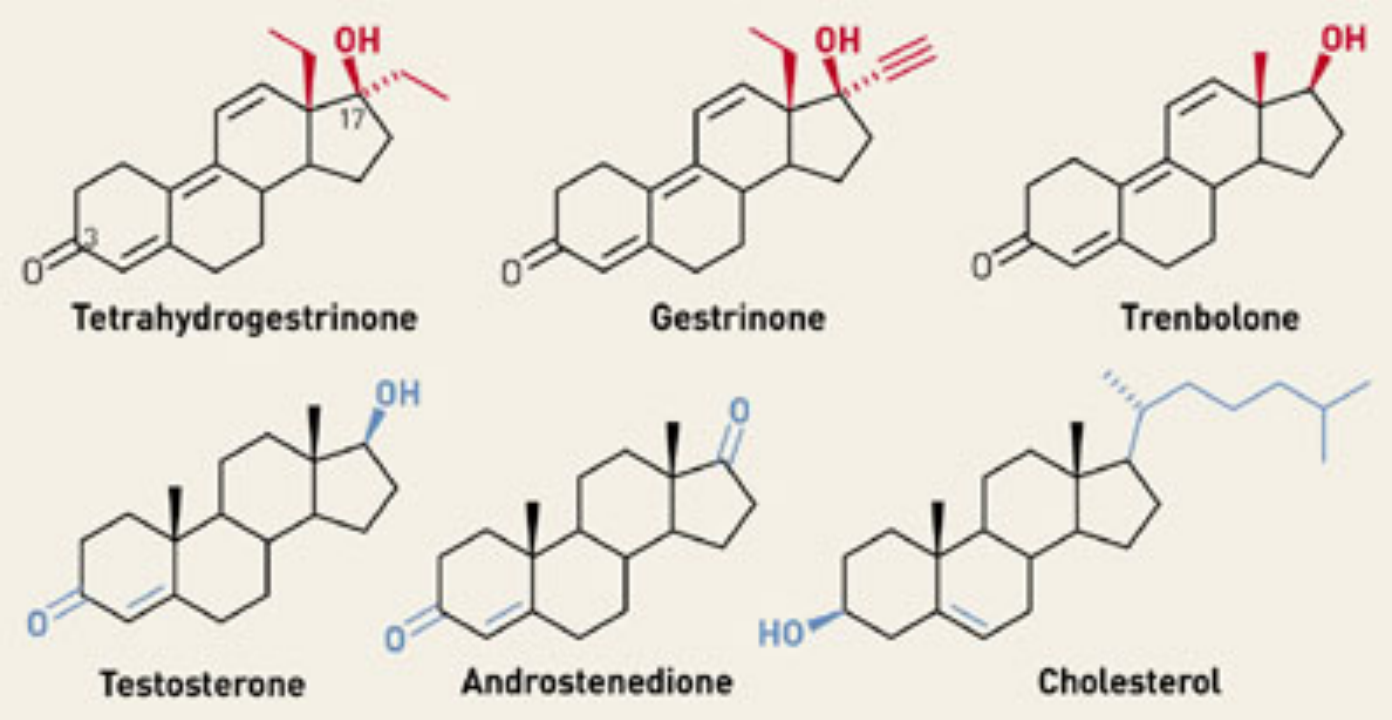
Methandrostenolone
(a synthetic tissue-building steroid)

http://www.cbsnews.com/videos/russias-dark-secret/

Anabolic Steroids

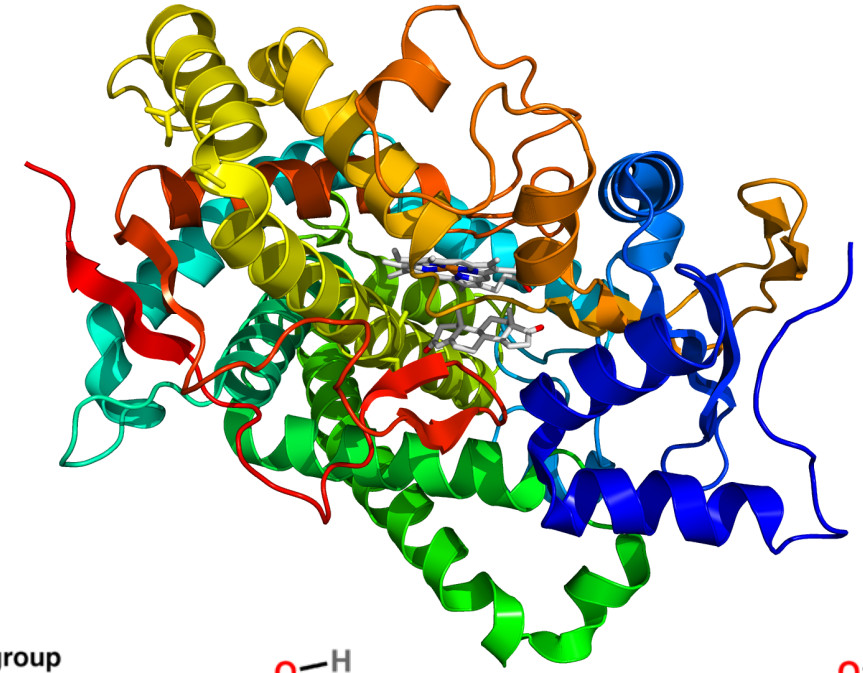
http://www.cbsnews.com/videos/russias-dark-secret/

Anabolic Steroids

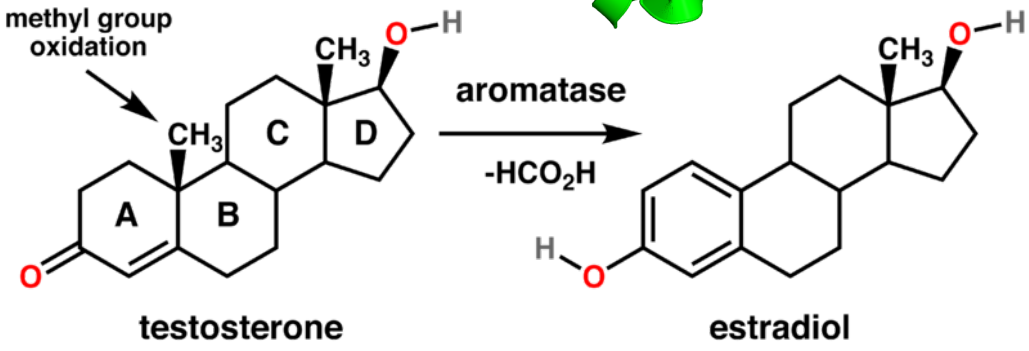


Enzyme Inhibition: Estrogen & Breast Cancer

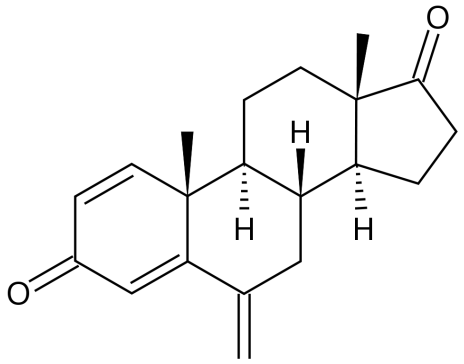
Inhibiting a cancer cell's division



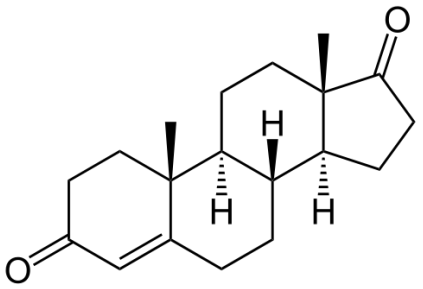
Cytochrome p450



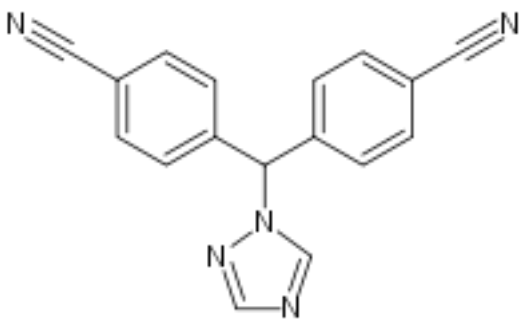
Enzyme Inhibition



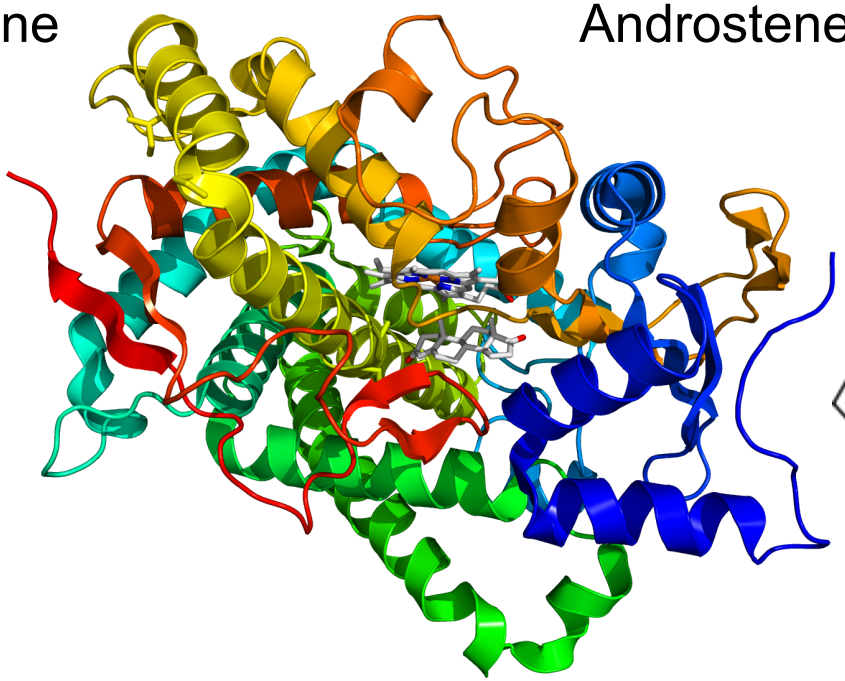
Exemestane



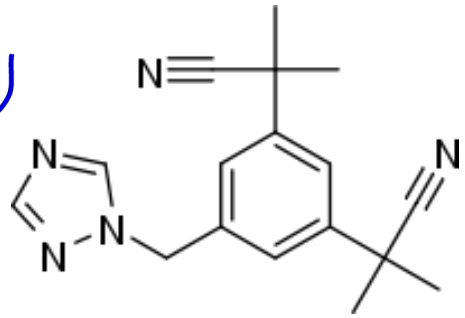
Androstenedione



Letrozole



Aromatase: Cytochrome p450



Anastrozole

Question

- Which of the following is not classified as a steroid?
- A) testosterone
- B) estradiol
- C) cortisone
- D) β-carotene