

Topic 10
Secondary Metabolites
Raven Chap. 2 (pp. 30-34), Chap 20 (497-498)

I. Plant Secondary Metabolites

A. Definitions

1) 1° vs. 2° Metabolism-

I. Plant Secondary Metabolites

B. Some 2° Metabolites

Compound	Example Source	Human Use
ALKALOIDS		
Codeine	Opium poppy	Narcotic pain relief; cough suppressant
Nicotine	Tobacco	Narcotic; stimulant
Quinine	Quinine tree	Used to treat malaria; tonic
Cocaine	Coca	Narcotic, tea, anesthetic, stimulant

I. Plant Secondary Metabolites

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PHENOLICS		
Tannin	Leaves, bark, acorns	Leather tanning, astringents
Salicin	Willows	Aspirin precursor
Tetrahydrocannabinol	Cannabis	Treatment for glaucoma & nausea

I. Plant Secondary Metabolites

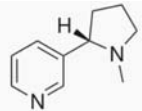
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TERPENOIDS		
Camphor	Camphor tree	Component of medicinal oils, disinfectants
Menthol	Mints & eucalyptus	Strong aroma; cough medicines

I. Plant Secondary Metabolites

C. Ecology

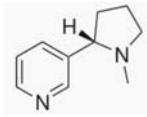
1. Defense
e.g., Nicotine




Steppuhn et al. 2004. *PLoS Biology* 2: 1074-1080.

I. Plant Secondary Metabolites

C. Ecology
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e.g., Nicotine

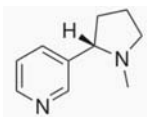


- Source: *Nicotiana tabacum*
- Neurotoxic to most herbivores





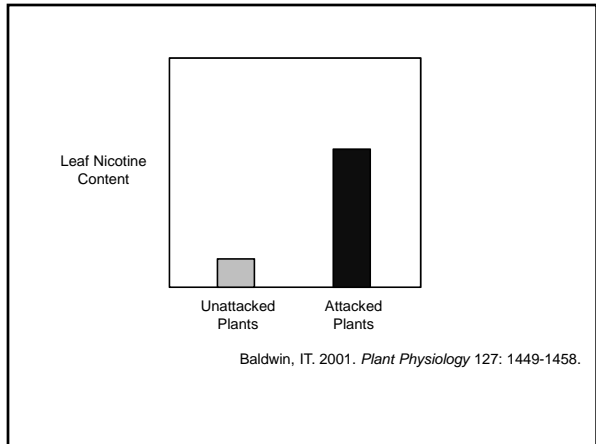
I. Plant Secondary Metabolites


C. Ecology
1. Defense
e.g., Nicotine




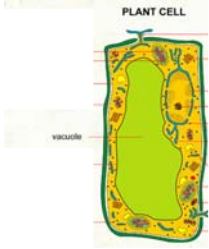
- Source: *Nicotiana tabacum*
- Neurotoxic to most herbivores
- But tobacco hornworm (a moth larva) can sequester & secrete it.





	Mechanism
	1. Herbivory induces jasmonic acid (JA) production.
	2. JA to roots, stimulates nicotine synthesis.
	3. Nicotine to shoots via xylem

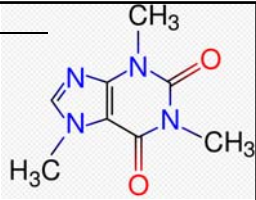
<u>I. Plant Secondary Metabolites</u>
C. Ecology
1. Defense
2. Attraction e.g., colors & floral fragrances

<i>Jasminum</i>

<u>I. Plant Secondary Metabolites</u>
D. Storage


II. Caffeine case study

A. Caffeine

- Alkaloid
- Coffea*, *Theobroma*, *Camellia*, *Cola*, etc.
- Psychoactive stimulant, diuretic


CN1C=NC2=C1C(=O)N(C)C2=O

II. Caffeine case study

A. Caffeine

- syn. w/ guaranine

Species: *Paulinia cupana* (guarana' vine)
Family: Sapindaceae
Nativity: S. America





II. Caffeine case study

A. Caffeine

- syn. w/ theine

Species: *Camellia sinensis* (tea bush)
Family: Theaceae
Nativity: S. Asia




II. Caffeine case study

A. Caffeine

-syn. w/ mateine

Species: *Ilex paraguariensis*
(yerba mate)
Family: Aquifoliaceae
Nativity: S. America.




II. Caffeine case study

A. Caffeine

-First IDed in *Coffea arabica*.

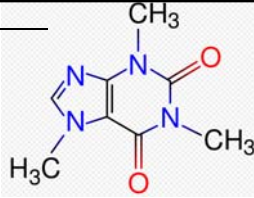
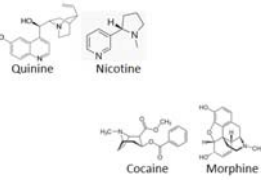
Species: *Coffea arabica*
(arabica coffee)
Family: Rubiaceae.
Nativity: NE Africa.



II. Caffeine case study

B. Alkaloids in general

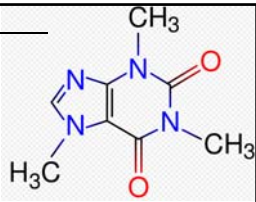
- Secondary metabolites
- Nitrogenous, cyclic

II. Caffeine case study

B. Alkaloids in general

- Secondary metabolites
- Nitrogenous, cyclic
- Psychoactive (act on CNS): herbivory defense



II. Caffeine case study

C. Ecological role of caffeine in nature

1. Excess can over stimulate CNS

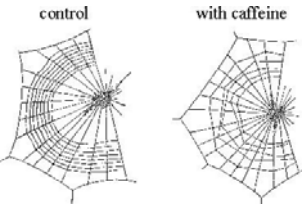
II. Caffeine case study

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1. Excess can over stimulate CNS

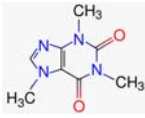
Spider web manufacture when influenced by caffeine.

control with caffeine



D. Caffeine's effects on CNS

- *Caffeine from coffee in blood w/in 5 min
- *Stimulates heart
- *Increases stomach acidity
- *Increases urine output
- *10% rise in metabolic rate



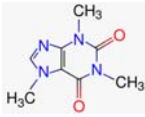
caffeine

- *Mimics feelings assoc. w/ adrenaline

***Excess (1 g; 10 cups) can cause anxiety, headache, dizziness, insomnia, heart palpitations, delirium, 4% lower birth weights.**

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caffeine

- *Mimics feelings assoc. w/ adrenaline

***Excess (1 g; 10 cups) can cause anxiety, headache, dizziness, insomnia, heart palpitations, delirium, 4% lower birth weights.**

***Ranks as most widely used psychoactive drug worldwide (coffee, tea, additives to soft drinks)**

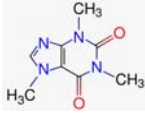
D. Caffeine's effects on CNS

How?

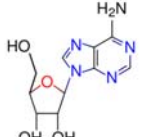
Antagonist of adenosine.

Adenosine:

- Attaches to brain cell receptors.
- Neurotransmitter inhibitor.
- Promotes sleep (accumulates in brain each waking hour).
- Suppresses arousal.



caffeine



adenosine

E. Caffeine and Parkinson's prevention?

What is Parkinson's Disease?

- no cure, just treatments
- Loss of muscular control: trembling arms and legs, trouble speaking, and poor coordination
- Associated with loss of dopamine-transmitting neurons in midbrain

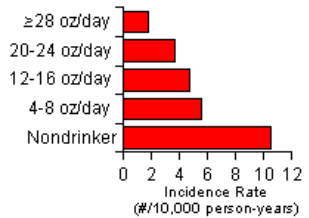
E. Caffeine and Parkinson's prevention?

What is Parkinson's Disease?

- no cure, just treatments
- symptoms of trembling arms and legs, trouble speaking, and difficulty coordinating movement
- Associated with loss of dopamine-secreting neurons in the midbrain.
- Dopamine levels fall, and the balance between dopamine and other neurotransmitters disrupted, affecting muscular control
- Blocking of adenosine receptors elevates levels of dopamine in brain.

E. Caffeine and Parkinson's prevention?

Honolulu Heart Program study of 8,000+ men over 30?

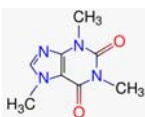


- Blocking of adenosine receptors by caffeine elevates levels of dopamine in brain.

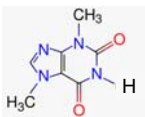
F. Caffeine and Theobromine are similar in structure and action

Table 1. Stimulant alkaloids in world's major stimulating beverages (Simpson 1986). Given in % weight. Amt. in particular beverage depends on how it is made.

Plant, part	Caffeine	Theobromine
Coffee, unroasted, dried seeds	1-1.5	--
tea, dried lvs.	2.5-4.5	--
Cacao, dried or fresh seeds	0.6-0.8	1.7-2.4
Kola, fresh seeds	2.0	--
Guarana, dried fruit	3.0-4.5	--



caffeine

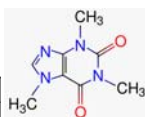


theobromine

G. Caffeine in some beverages

Table 2. Caffeine quantities in select beverages.

Drink	Caffeine (mg)
Coffee (Starbucks)	
12 oz drip	240
1 oz espresso	?
12 oz drip decaf	19

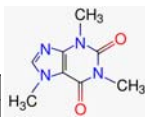


caffeine

G. Caffeine in some beverages

Table 2. Caffeine quantities in select beverages.

Drink	Caffeine (mg)
Coffee (Starbucks)	
12 oz drip	240
1 oz espresso	75
12 oz drip decaf	19



caffeine

Table 6. Average caffeine content in products (most amounts from the Center for Science in the Public Interest, 2007; chocolate amounts from Simpson and Orzogoly 1996).

Product	Caffeine (to the nearest mg)
Coffee (Starbucks)	
12 oz drip coffee	240
1 oz espresso	75
12 oz drip decaf coffee	19
Tea (various)	
12 oz brewed tea	80 (60-180)
12 oz Nestea	26
12 oz Snapple	14-32
Cocoa and chocolate (various)	
12 oz, from powder	14 (4.5-20)
1 oz baking choc	35
1 oz dark choc	20
1 oz milk choc	6
Soda (various)	
8.3 oz Red Bull	80
12 oz Jolt Cola	72
12 oz Mountain Dew	54
12 oz Dr. Pepper	42
12 oz Pepsi	38
12 oz Coca-Cola Classic	35



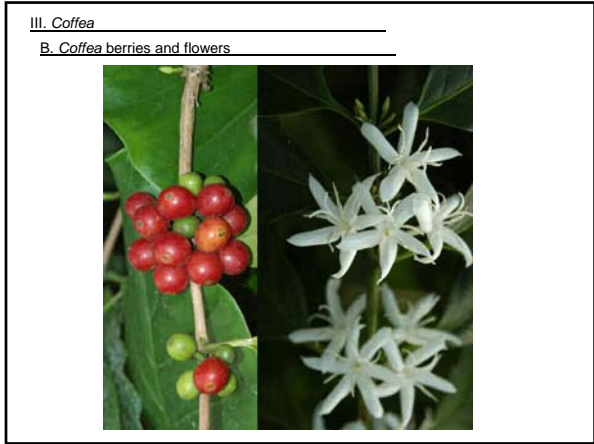
III. Coffea

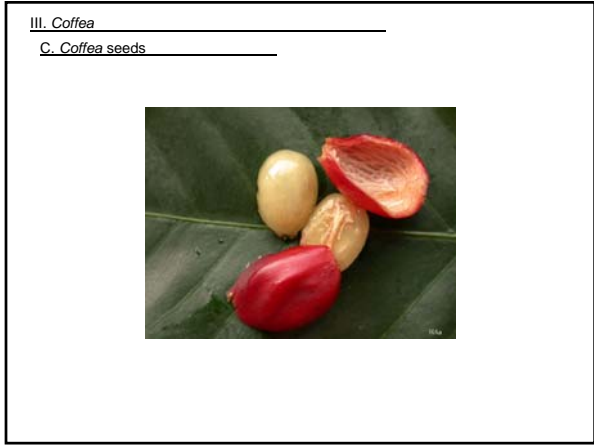
A. Sysematics

- Genus *Coffea*
- Coffea* contains nearly 100 spp., tropical Africa & Asia
- Commercial spp: *C. arabica*, *C. canephora*, *C. liberica* (all African)

III. Coffea

B. Coffea berries and flowers







III. *Coffea*

D. Coffee is a major commodity globally.


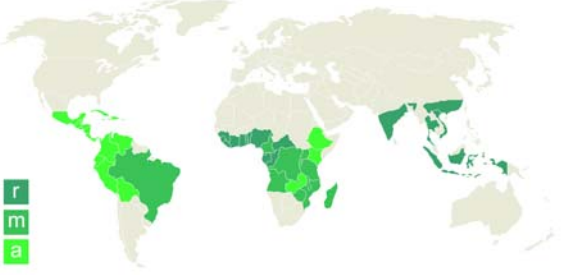



Table 3. Production of top 3 stimulant beverages.

Top 3 continents	Total (MT)
Coffee	5,919
1. S Amer	
2. Africa	
3. N & C Amer	
Tea	2,473
1. Asia	
2. Africa	
3. S Amer	
Cocoa	2,329
1. Africa	
2. S Amer	
3. Asia	

III. *Coffea*

D. Coffee is a major commodity globally.



World map showing coffee production regions in green. The regions include South America, Central America, the Caribbean, East Africa, and Southeast Asia. A small logo with the letters 'r', 'm', and 'a' is visible in the bottom left corner of the map area.

III. *Coffea*

Coffee Biotech Group (Campinas, Brazil)



III. Coffea

E. Coffee origins

Coffea arabica, Ethiopian highlands

- Relatively few Africans drink it.
- Traditionally chewed leaves & fruits.
- Relief of fatigue, hunger on hunts.



Farmer in Ethiopia

E. Coffee (the drink) developed in Yemen

Arrival in Yemen 13-14 century, where it was first brewed (hence, *Coffea arabica*).



ca. 1900

1102—A Coffee-house in Palestine.

F. Coffee timeline

1. Yemen 13-14th century.
2. Arabia to Egypt by 1510.
3. To Italy & Europe by 1616.
4. Vienna priests threatened by "coffee culture", but Pope Clement VIII would not ban coffee.
5. To England by 1650 and coffee houses became important socio-political institutions.
6. Europe looked to break Arabian monopoly on production.
(Arabs killed embryos in seeds before export).

7. Spread of Coffee production

- Dutch obtained live seeds from Mocha (Red Sea Coast, Yemen, 1706)
- Throughout Dutch colonies in Indonesia (e.g., Java) and to S America by 1717.
- Today, Brazil is world's leading producer.

