Ethnobotany. Lecture 9

Alexey Shipunov

Minot State University

February 2nd, 2011

Outline

Minot State UNIVERSITY

Lab 2 classifications

- Thickened roots or tubers $\Rightarrow$ starch-containing plants
- Well-developed, maybe succulent leaves $\Rightarrow$ vegetables
- Large fruits $\Rightarrow$ fruits
- Showy flowers $\Rightarrow$ ornamentals, and/or sources of nectar for bees, and/or sources of dyes
- Spiny $\Rightarrow$ plants for hedges (technical)

Mistakes: multiple bases (like “vines” and “edible”), plants with effects (like “medicinal” or “psychoactive”), groups based on plant characters instead of human use; groups based on similarities with known plants (looks like apple $\Rightarrow$ may be used like apple)

Minot State UNIVERSITY

Sugar cane, *Saccharum officinarum*

- Belongs to grass family, Gramineae; it is a C_4 grass
- The oldest cultivated sugar plant
- Contains sugars in stem

Sugar cane

Sugar cane biology

- Extremely tall grass, up to 6 m tall (!)
- Stem phloem* juice contains 12–20% of sucrose in lower parts of stem
- Juice is pressed, filtrated, evaporated, centrifuged (to separate syrup from sugar crystals) and dried

Sugar cane agriculture

- Grafted culture, it is not recommended to wait until flowering
- Short-day, sun-loving plant, optimal temperatures should be > 20° C
- Requires irrigation even in humid tropics (!) and significant amounts of phosphorous
- Vegetation period is up to 250 days

Sugar cane history

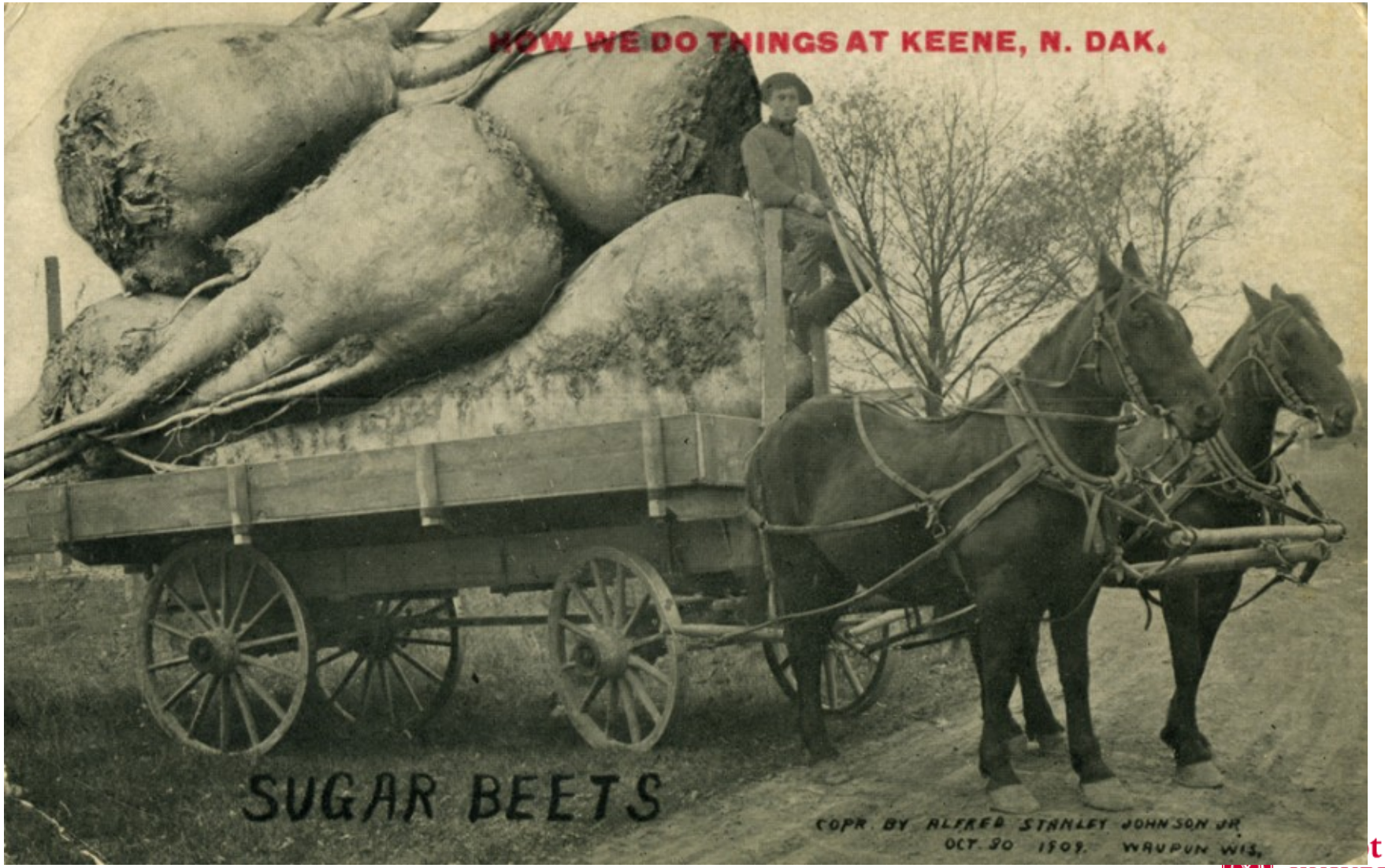
- The culture started in Indian center, then moved to China and with Arabs—to Europe (Spain, 1150 AD)
- Arabs first invented white, filtrated sugar
- Went to Central and South America in XVI century (Europe needs sugar but it was not growing well there!).
- Now cultivated in tropical America, Africa and Asia (top producers are Brazil and India) but culture is declining under the pressure of competition with sugar beet
- Etymological dictionary says that:

sugar: late 13c., from O.Fr. sucre “sugar” (12c.), from M.L. succarum, from Arabic sukkar, from Pers. shakar, from Sanskrit sharkara “ground or candied sugar,” originally “grit, gravel”

Sugar beet, *Beta vulgaris* var. *saccharifera*

- Amaranth family, Amaranthaceae (or Chenopodicaceae in older classifications)
- Same species with vegetable beet
- Has been selected from leaf and root beets for only 300 years: one of the youngest cultures
- Root contains up to 20% of sucrose

Sugar beet from North Dakota! (that's a joke photo)



Sugar beet biology

- Biennial plant: first year with rosellate leaves, second year forms stem with non-showy flowers
- The “root” is actually intermediate structure between stem and root in strict sense—hypocotyl
- Has anomalous secondary growth (layers of tissues)
- Roots are “white”: do not contain betalain (red pigment which probably helps red beet to protect tissues from fungi and animals)

Sugar beet agriculture

- Hardy plant: North Dakota is one of the leading states in sugar beet cultivation
- Yield is typically $\approx$70 ton/hectare (wet mass), and 12 ton/hectare (pure sugar): compare with $\approx$100 and $\approx$10 for sugar cane
- Some plants should be left for seeds (second year)
- Susceptible for weeds (needs herbicides)

Sugar beet history

- In 1747, the sucrose content was discovered
- In 1810s, due to continental blockade of France, sugar mills were established across all Europe
- In XX century, sugar production was almost doubled
- Leading countries now are France, Germany and U.S.; one of biggest research centers is NDSU

Sugar maple, *Acer saccharum*

- Tree from Sapindaceae (Aceraceae in older classifications) family
- Old semi-cultivated plant of eastern tribes of Native Americans
- Spring sap is the main source of sugar

Sugar maple

Native sugar-making

Sugar maple features and history

- Sap contains 2–5 % of sucrose, the season starts in early spring and continues 4–8 weeks
- In total one tree could produce up to 50 liters of sap per season for 60–70 years (from 30–40 to 100 years old)
- Production increased during Civil War
- Leading producer is Canada (Quebec)
- Analogous birch syrup from *Betula* is more poor, only 1–2% of sugars

Sugar collection

Sugar evaporation

Sweet sorghum, *Sorghum saccharatum*

- Grass, selection started in 1940s
- Similar in agriculture, but much less demanding plant than sugar cane
- 10–20% of sucrose in stems
- Now cultivated mostly in U.S. and Argentine

Sweet sorghum

Arenga sugar palm, *Arenga pinnata*

- Belongs to palm family, Palmae
- The source of “gur” sugar and also wine
- Inflorescences are used for taking sap (17–20% of sucrose)

Arenga sugar palm

Arenga sugar palm features and history

- Syrup are very easily inverted (hydrolyzed into glucose and fructose) and should be evaporated as soon as possible
- Every day, palm tree gives 5–7 liters of sap; the season is up to 8 weeks
- Old Indian culture spread into south-east Asia

Collection of palm sap

Toddy, *Caryota urens*

- African sugar palm, one of the largest palms
- Monocarpic tree, dies after flowering
- Since the sap is fermented fast, it mostly used as a source of palm vine ($\approx$1% of alcohol)
- Starred in groundbreaking novel “The Palm Wine Drinkard” by Nigerian author Amos Tutuola

Toddy palm

Toddy palm on flowering stage

Palm-wine drinkard

Mezcal, tequila agave, *Agave tequilana*

- Monocarpic Mexican plant from asparagus family (Asparagaceae)
- The sap is rich of sugars, mostly fructose
- Used mostly for alcohols like mezcal, pulque and tequila

Mezcal

Yacon, *Smallanthus sonchifolius*

- Belongs to aster family, Compositae
- Roots are rich of inulin, fructose and fructo-oligosaccharides (FOS) such as kestose (F2)—“alternative sweeteners”
- Traditional Andean culture; had ceremonial importance in times of Mochica culture (Peru, 100–800 AD)

Yacon roots

Yacon plant

Japanese raisin tree, *Hovenia dulcis*

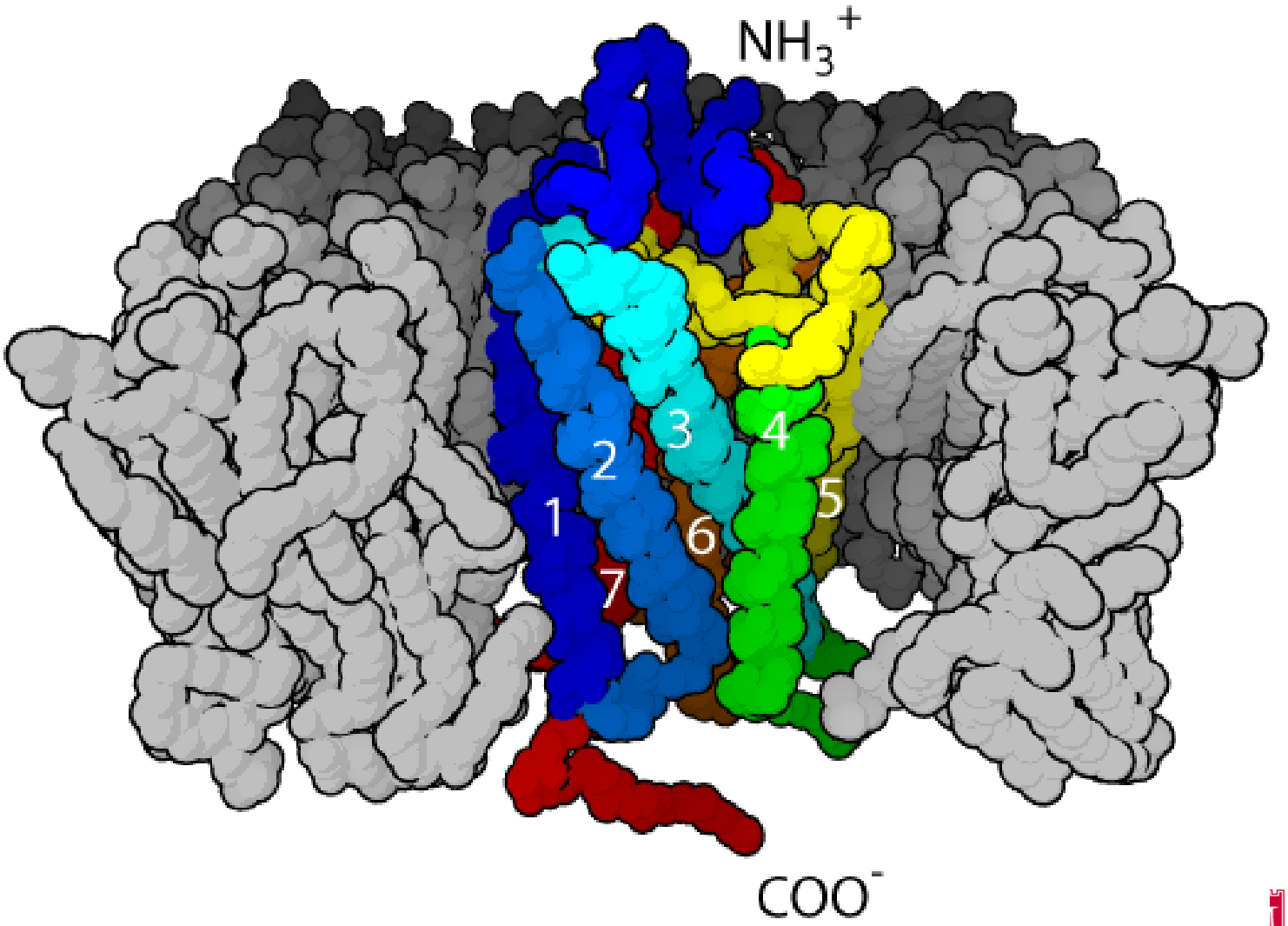
- Large East Asian tree from buckthorn family, Rhamnaceae
- Large fruit stalks (“subsidiary fruits”) may be used as replacement for honey
- Has several medicinal properties (e.g., helps recovery from alcoholism)

Japanese raisin tree

What is sweetness?

- Nature of sweetness is not yet fully discovered
- Probably due to specific Van der Waals forces occurring in variety of molecules
- These molecules have an effect on sweet receptors—large proteins from G protein-coupled receptors (GPCRs) group

GPCR, sweetness receptor



Miracle fruit, *Synsepalum dulcificum*, the super-sweetener

- West African tree, belongs to tropical Sapotaceae family
- Berries convert sour tastes into sweet tastes (!), effect lasts for $\approx$1 hour
- The effect is due to glycoprotein miraculin which is binding to sweet receptors
- Cultivation is now starting in Florida, approval as food additive is pending—it is heat-resistant and may be used as a “sweetener”; there are genetically modified lettuce plants which produce miraculin
- Curculin from *Curculigo latifolia* (“lumbah-lumbah”), Malaysian herb from Hypoxidaceae family, has the same effect + it is also super-sweet by itself (500–2000 times sweeter than sucrose)

Miracle fruit

Miraculin glycoprotein

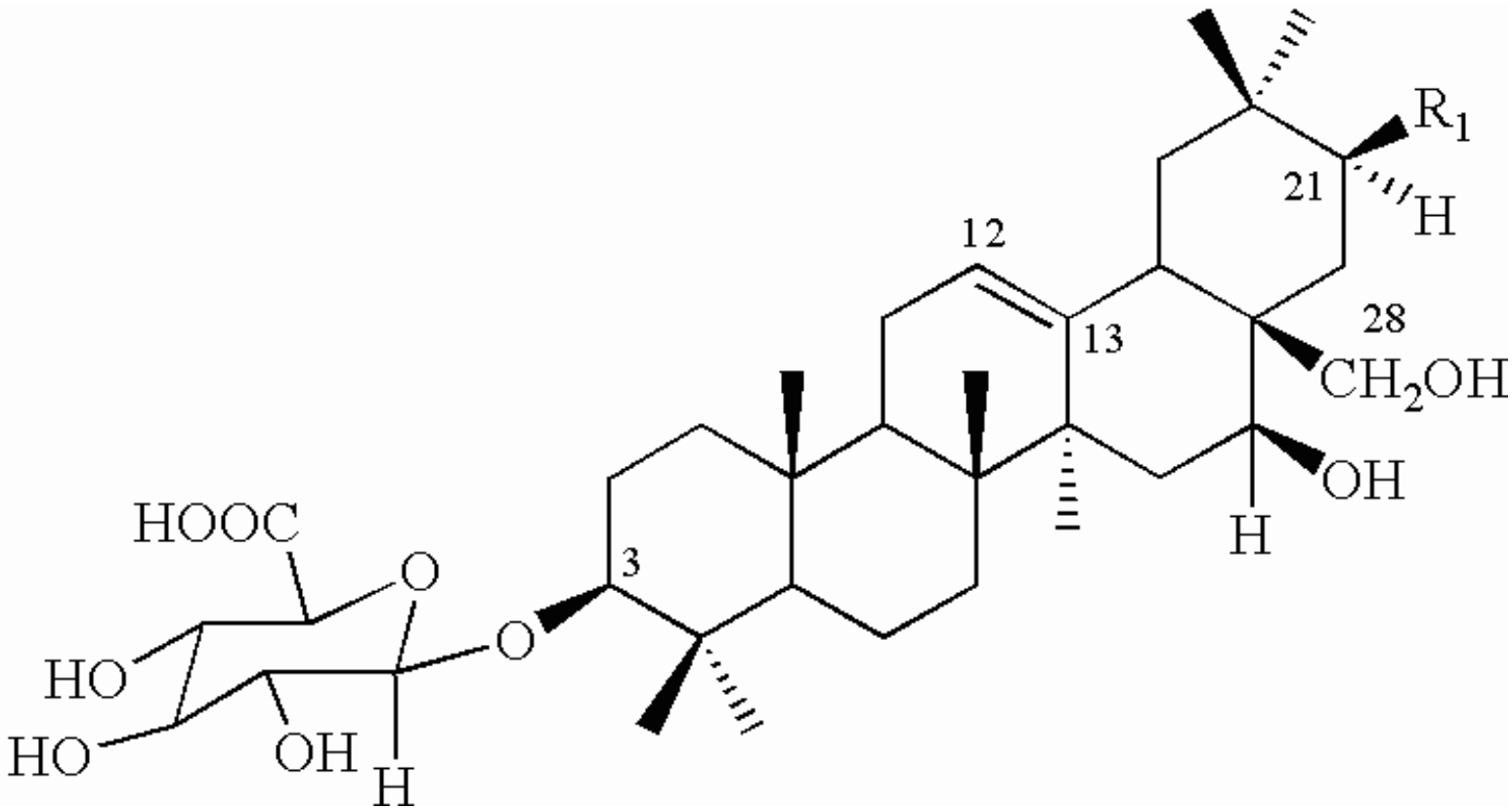
Lumbah-lumbah

Anti-sweeteners

- Several plants contain chemicals which are able to suppress sweet receptors
- Indian herbaceous vine *Gymnema sylvestris* from a dogbane family (Apocynaceae) contain gymnemic acids which suppress sweet taste for $\approx$10 min
- In addition, plant has an unrelated (?) effect in lowering blood sugars
- Used as a drug for curing Type 2 diabetes and different forms of metabolic disorders

Gymnema sylvestre

Gymnemic acid



Summary

- Two plants produce more than 2/3 of sugars: sugar beet (production is increasing) and sugar cane (decreasing)
- Many tropical sugar plants are used mostly for alcohol production
- Sweet taste still has undiscovered nature

For Further Reading

A. Shipunov.
Ethnobotany [Electronic resource]. 2011—onwards.
Mode of access:
http://ashipunov.info/shipunov/school/biol_310

P. M. Zhukovskij.
Cultivated plants and their wild relatives [Electronic resource].
Commonwealth Agricultural Bureaux, 1962.
Mode of access:
http://ashipunov.info/shipunov/school/biol_310/zhukovskij1962_cultivated_plants.pdf
Pages 14–16.

Minot State UNIVERSITY