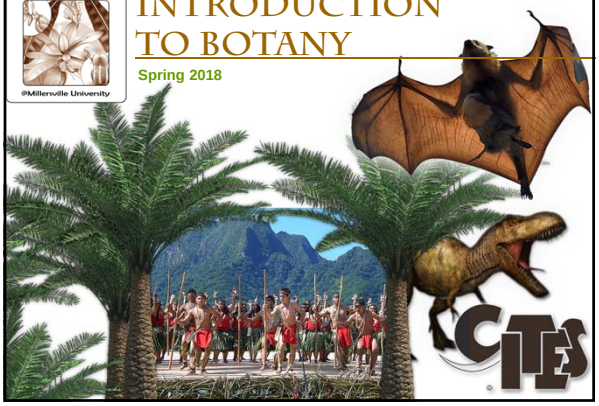
Read also: Banack et al. 2006. *J Ethnopharmacology* 106: 97-104.

INTRODUCTION TO BOTANY

Spring 2018



I. Cycads Overview

A. What's a cycad?

1. Palm-like trees & shrubs

I. Cycads Overview

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2. Related to Conifers (Gymnosperms)

I. Cycads Overview

A. What's a cycad?

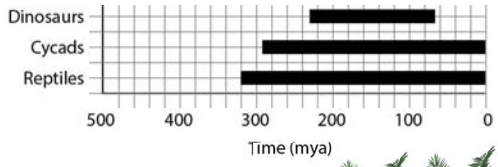
1. Palm-like trees & shrubs
2. Related to Conifers
3. An ancient lineage

Jurassic Diorama. Credit: Alfred F. Harrell, 1977 (Smithsonian Institution)

I. Cycads Overview

A. What's a cycad?

1. Palm-like trees & shrubs
2. Related to Conifers
3. An ancient lineage
4. Rose to prominence during the rise of reptiles; Predate & outlast the dinosaurs & angiosperms



I. Cycads Overvie

B. Ecology

1. Beetle-pollinated
   - Not wind-pollinated like conifers
2. Seeds dispersed by fruit bats
   - Fleshy, colorful seed coat attracts fruit bats (flying foxes)

I. Cycads Overview

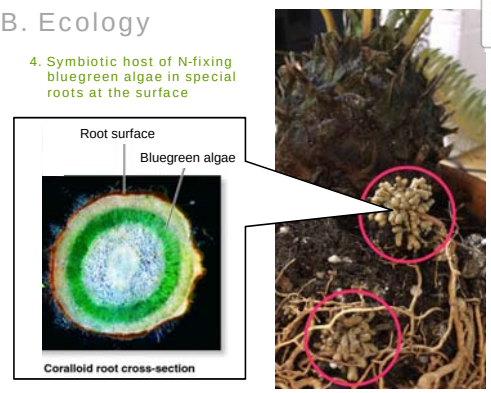
B. Ecology

3. Herbivory Defense via Chemistry:
   Toxins in all parts (esp. pollen & seeds) defend against herbivory

I. Cycads Overview

B. Ecology

4. Symbiotic host of N-fixing bluegreen algae in special roots at the surface



I. Cycads Overview

C. Ethnobotany

1. Starch ("sago") from stems & seeds

Queen Sago Palm (*Cycas circinalis*)

I. Cycads Overview

C. Ethnobotany

1. Starch ("sago") from stems & seeds
2. Medicines
   - Bio-active chemistry (toxins) have various applications in low doses.

I. Cycads Overview

C. Ethnobotany

1. Starch ("sago") from stems & seeds
2. Medicines
3. Ornamentals
   - Highly sought-after
   - Mystique of age & rarity

I. Cycads Overview

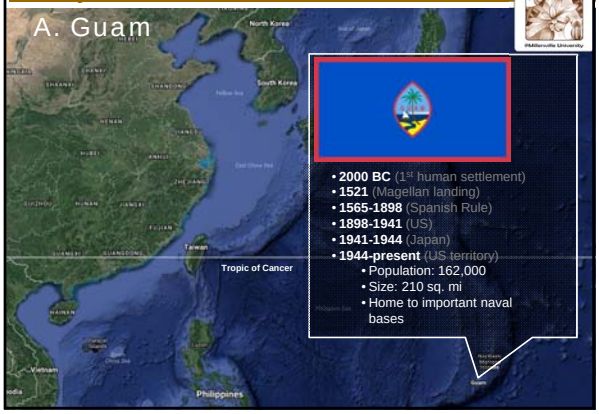
C. Ethnobotany

1. Starch ("sago") from stems & seeds
2. Medicines
3. Ornamentals
4. Conservation
   - Vulnerable to extinction if trade is unregulated
   - Protected under CITES
   - Illicit trade is a multi-million $ industry

II. Cycads & Guam ALS-PDC

II. Cycads & Guam ALS-PDC

A. Guam



- **2000 BC** (1st human settlement)
- **1521** (Magellan landing)
- **1565-1898** (Spanish Rule)
- **1898-1941** (US)
- **1941-1944** (Japan)
- **1944-present** (US territory)
  - Population: 162,000
  - Size: 210 sq. mi
  - Home to important naval bases

II. Cycads & Guam ALS-PDC

B. Guam ALS-PDC (*Iytigo-bodig*) Epidemic

1. Mysterious progressive neurodegenerative disease
   - becomes the leading cause of death among Chamorro mid-20th century

II. Cycads & Guam ALS-PDC

B. Guam ALS-PDC (*lytigo-bodig*) Epidemic

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   - becomes the leading cause of death among Chamorro mid-20th century
2. Symptoms
   - *Lytico* = prog. Paralysis resembling Amytrophic Lateral Sclerosis
   - *Bodig* = Parkinsons w/ Alzheimers-like dementia

II. Cycads & Guam ALS-PDC

B. Guam ALS-PDC (*lytigo-bodig*) Epidemic

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2. Symptoms
   - *Lytico* = prog. Paralysis resembling Amytrophic Lateral Sclerosis
   - *Bodig* = Parkinsons w/ Alzheimers-like dementia
3. Prognosis
   - Death < 10 years from diagnosis

II. Cycads & Guam ALS-PDC

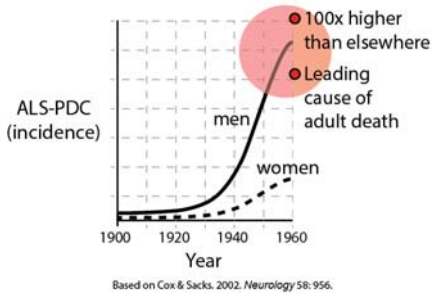
C. Chamorro

1. Historically very healthy

II. Cycads & Guam ALS-PDC

C. Chamorro

1. Historically very healthy
2. ALS-PDC epidemic

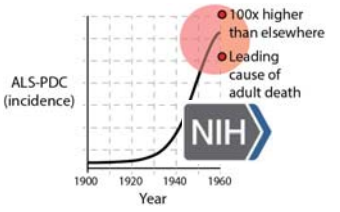


Based on Cox & Sacks. 2002. *Neurology* 58: 956.

II. Cycads & Guam ALS-PDC

C. Chamorro

1. Historically very healthy
2. ALS-PDC epidemic
3. NIH steps in

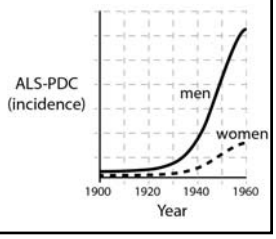


II. Cycads & Guam ALS-PDC

D. NIH

1. 1940s-1990s (Genetic Hypothesis)

Evidence for
- Endemic to Chamorro
- Primarily in men



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Evidence for
- Endemic to Chamorro
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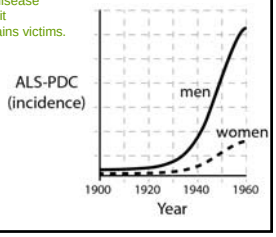
Evidence against
- Chamorro emigrants don't contract disease
- NonChamorran immigrants contract it
- Neurotoxin called BMAA found in brains victims. (Likely the cause of ALS-PDC)
- Why now?

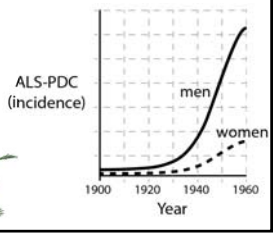


II. Cycads & Guam ALS-PDC

D. NIH

1. 1940s-1990s (Genetic Hypothesis)
2. 1970s-1990s (Cycad Hypothesis)

Evidence for
- Neurotoxin (BMAA) from cycad pollen & seeds found in brains of victims
- NIH assumes that cycad pollen inhalation could be route for BMAA exposure
- NIH also knows that seeds used for traditional Chamorro flatbread & dumplings



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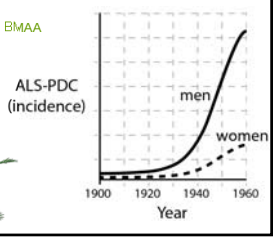
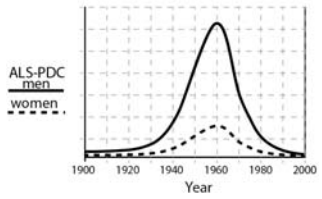
Evidence against
- Beetles, not wind, carry pollen
- Chamorro pre-treat seeds to remove BMAA
- Why now?



II. Cycads & Guam ALS-PDC

D. NIH

1. 1940s-1990s (Genetic Hypothesis)
2. 1970s-1990s (Cycad Hypothesis)
3. 1990s (ALS-PDC fading away, NIH gives up)



II. Cycads & Guam ALS-PDC

E. Paul Cox & Oliver Sacks (2002-onwards)

Oliver Sacks (1933-2015)

- **Neurologist** (pioneering discoveries on links between brain chemistry & neurological disorders)

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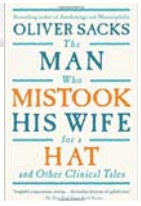
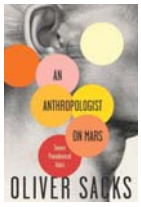
- **Popular Author**

1973



1985

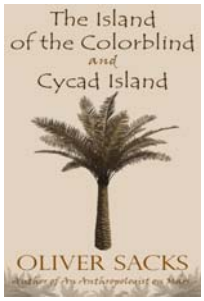


1995

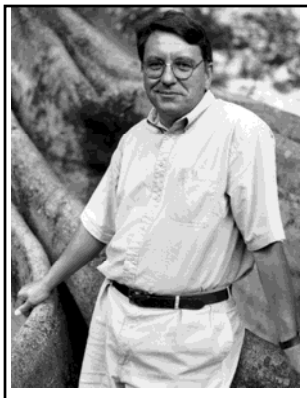
1990

Oliver Sacks (1933-2015)

- Neurologist (pioneering discoveries on links between brain chemistry & neurological disorders)
- Popular Author
- **Cycad Enthusiast**



1997



Paul Cox (b. 1953)

- **Botanist** (studies ethnomedicine of Pacific Islands; cure for ALS)
- **Then:** Inst. Ethnobotany, NTBG, Hawaii
- **Now:** Inst. Ethnomedicine, Wyoming

II. Cycads & Guam ALS-PDC

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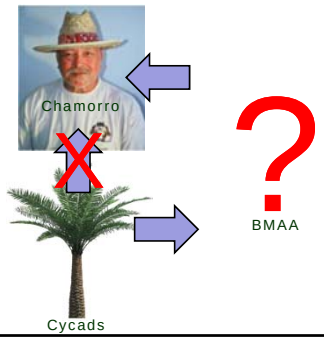
A new angle on the Cycad Hypothesis



Traditional Chamorran delicacy

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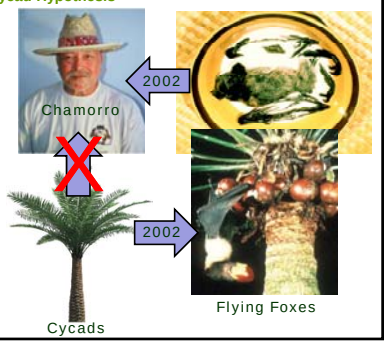

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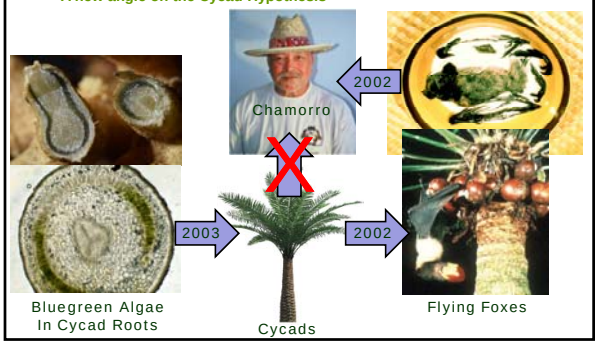

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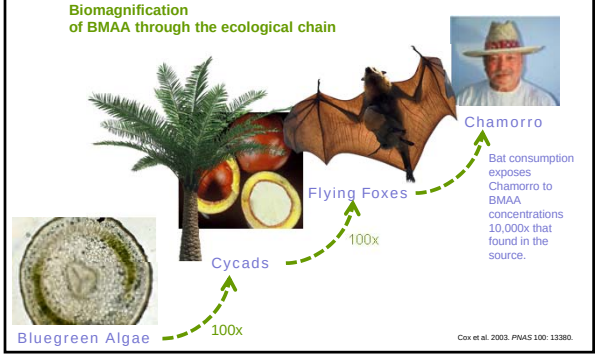
Biomagnification
of BMAA through the ecological chain

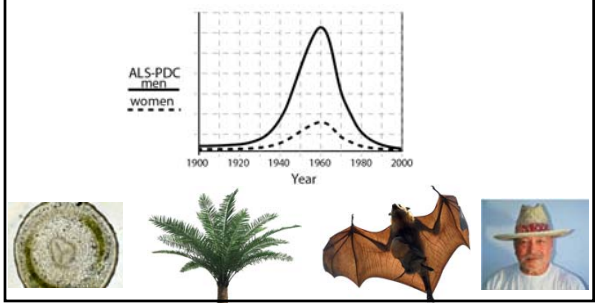


II. Cycads & Guam ALS-PDC

E. Paul Cox & Oliver Sacks (2002-onwards)

Cycad-Bat Theory explains:

- Sex bias (primarily men eat the bats)
- Immigration & emigration phenomena (eating bats is a cultural phenomenon)



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Cycad-Bat Theory explains:

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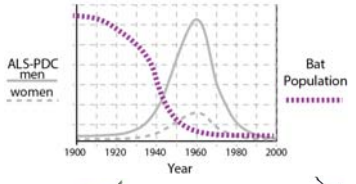
- Increase & decline of ALS-PDC in 20th century?



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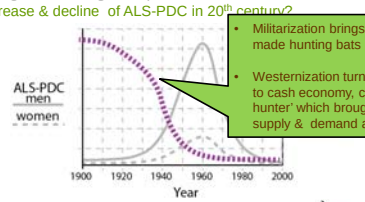

- Militarization brings guns, which made hunting bats more efficient
- Westernization turned subsistence to cash economy, creating the 'bat hunter' which brought increased supply & demand at market

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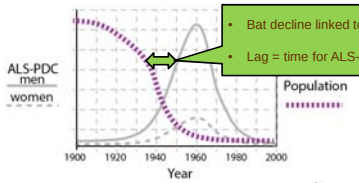

- Bat decline linked to rise of ALS-PDC
- Lag = time for ALS-PDC to develop

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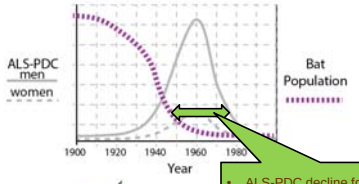
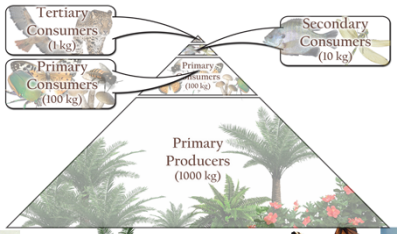


- ALS-PDC decline follows decline of bat supply.

III. Why Study Botany?

A. Basic Biology

- Laws of thermodynamics (embodied by the 10in this biomass pyramid) show that plants & algae comprise 90%



III. Why Study Botany?

A. Basic Biology

B. Lessons from Cycads & Guam

- NIH spent decades in Guam but was not able to crack this case.
- Integrating basic cycad botany & Chamorran anthropology was key:
  - Symbiotic relationships between cycads and bluegreen algae
  - Cycads concentrate algal toxins in tissues as defense against herbivores
  - Bats disperse cycad seeds (eat the fleshy seed coat, discard the seeds)
  - People eat the bats

III. Why Study Botany?

A. Basic Biology

B. Lessons from Cycads & Guam

C. **Beyond Guam**

- **How much of neurodegenerative disease is genetic vs. environmental?**
  - BMAA found in Alzheimers patients in Canada.
  - Are other toxins also contributing to the increasing incidence of such diseases?
  - Are bluegreen algae found in global water supplies a problem?
  - Why are fruits bats unaffected by BMAA yet people are?

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  - Why are fruits bats unaffected by BMAA yet people are?
- **Truly great discoveries come from integrative approaches.**
  (That course in botany may come in handy one day.)