

Deuterium: An accurate travel log for migratory birds?

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Tracking migratory birds by traditional proxies

Bird banding

- Low recovery rates
- Relies on Cooperation



N.A. Band recoveries (1955-2000)

Species	Banded	recap	%
Canada Goose	2,991,538	594,114	19.9
Mallard	5,935,960	878,704	14.8
N. Pintail	1,286,499	142,449	11.1
Merlin	26,308	674	2.6
Logg. shrike	22,897	196	0.86
Sp. sandpiper	13,673	79	0.58
R-t. hummingbird	54,218	53	0.10
Am. redstart	275,222	256	0.09
Myrtle warbler	824,013	704	0.09
W. flycatcher	28,194	20	0.07
Sw. thrush	371,313	251	0.07

} Game
Species

Tracking migratory birds by traditional proxies

Radio transmitters

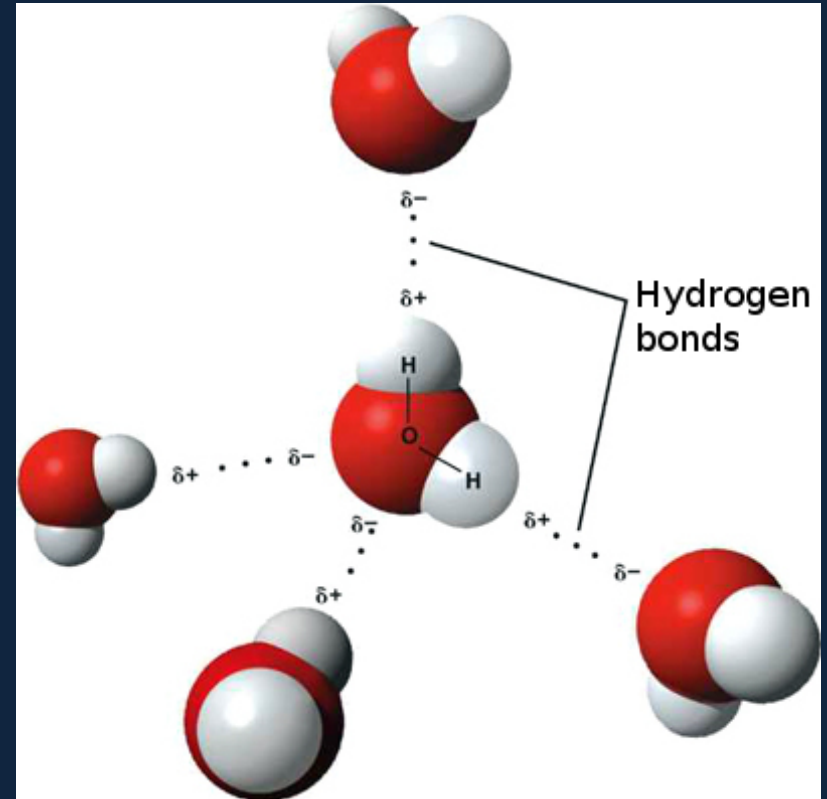
- Size requirements
- Behavioral effects (weight is an important factor in flight)
- Damage and loss of tracking device



Solution: An intrinsic marker

Deuterium

- Deuterium water
- Important properties:
 - A. Stronger IMF's
 - B. Higher boiling point (stronger H-bonding)
→ evaporative fractionation



*In simple terms: It's all about solvation!!

Measurement and Notation

- Notation: reported in “per mil” or ‰

$$\delta D = 1000 \times \left(\frac{R_{\text{sample}} - R_{\text{standard}}}{R_{\text{standard}}} \right)$$

R = molar abundance D/molar abundance of H

Jargon:

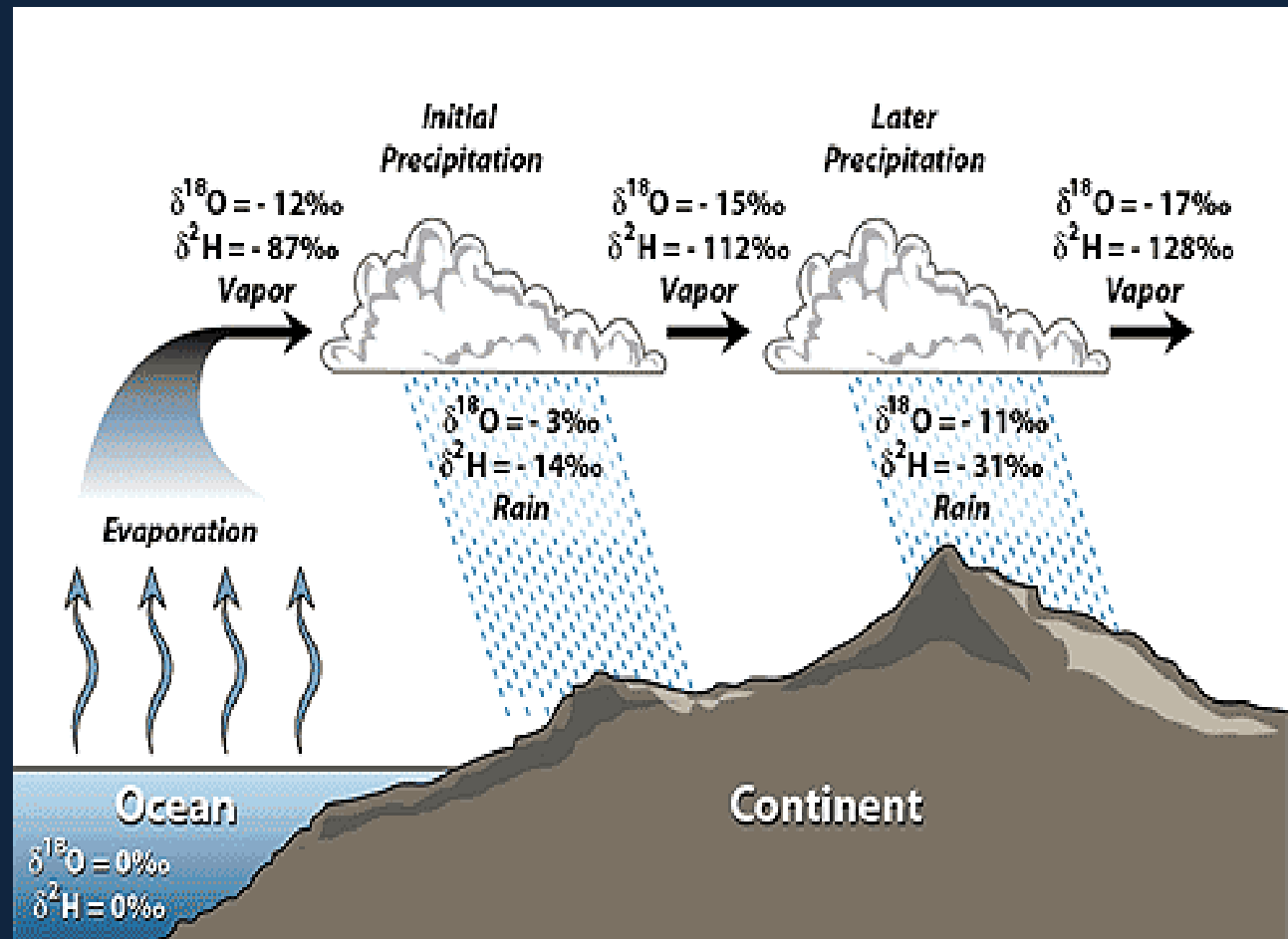
- if δD is positive, sample is D enriched
- if δD is more negative, we call it depleted and it has less D than standard (Vienna Standard Mean Ocean Water)

So what?

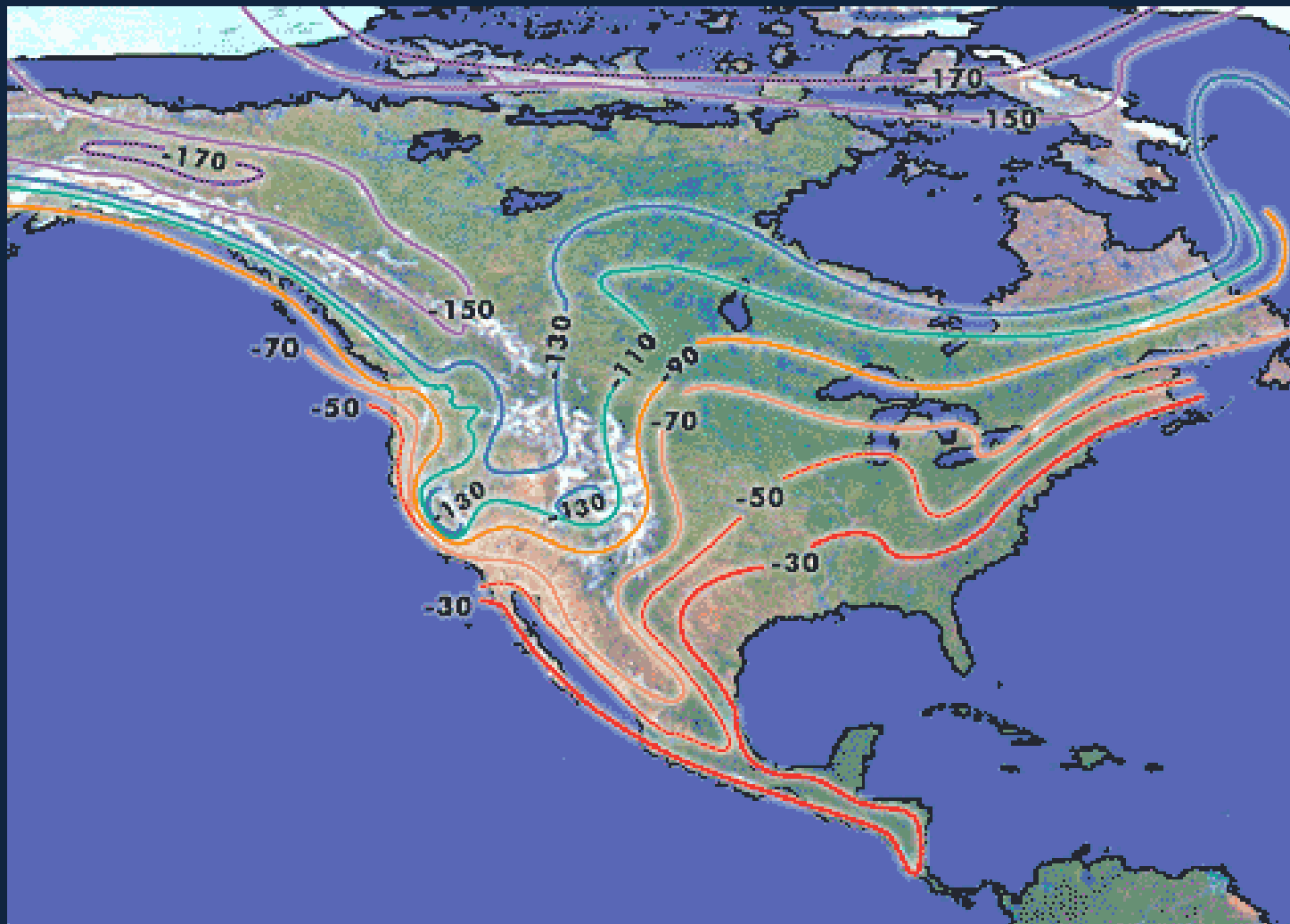
- Continental deuterium gradient

-2 factors involved:

1. Air pressure
→ elevation
2. Temperature
→ latitude & elevation



Result: Continental Gradient



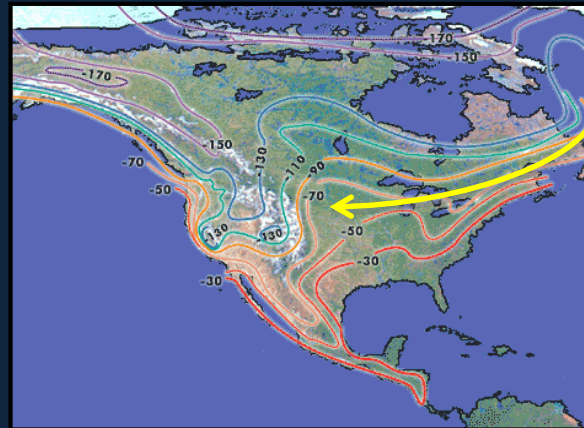
What does this mean to ecologists?

If...

- $\delta D_{\text{Feather}} = \delta D_{\text{Precipitation}}$
- Predictable molting and regrowth

Then...

→ We can track birds with hydrogen values



Years of Research



Hobson et al. 1987



Marra et al. 1998



Rubenstein et al. 2002



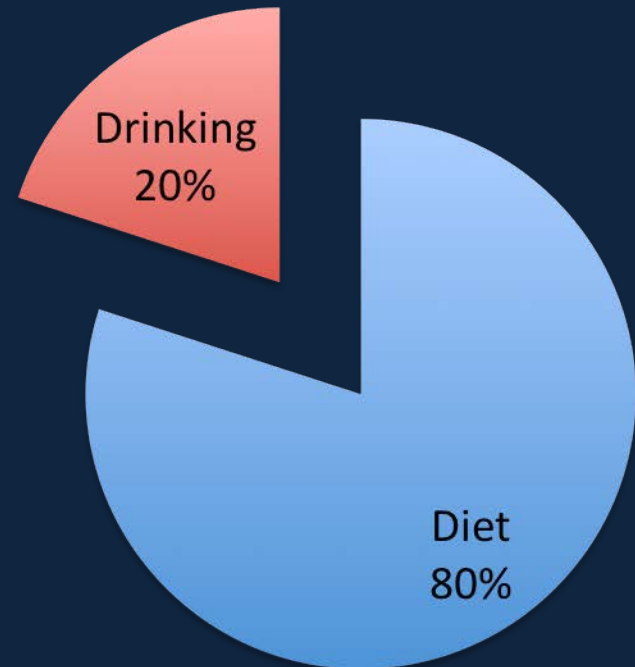
Lott and Smith 2006



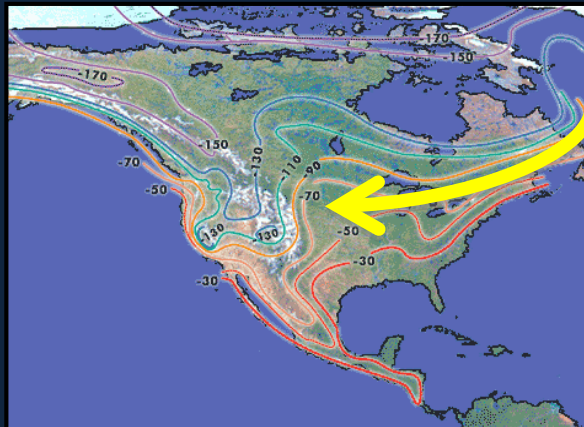
Before I was even born!!!

The problem

- HUGE assumption
- Only ~20% of hydrogen in tissues derived from drinking water

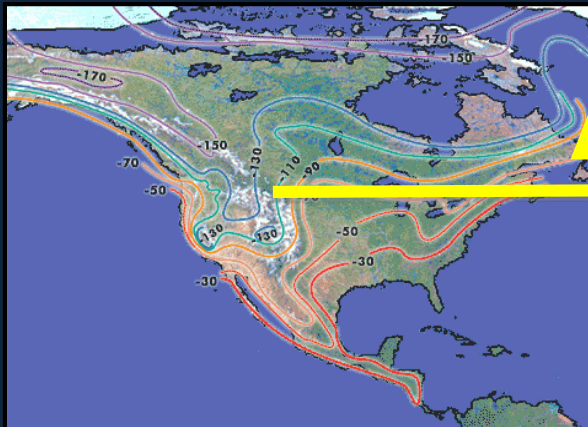
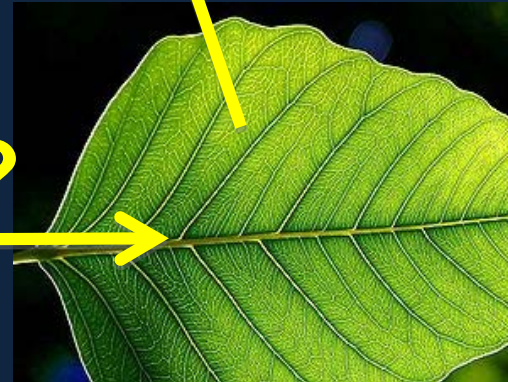
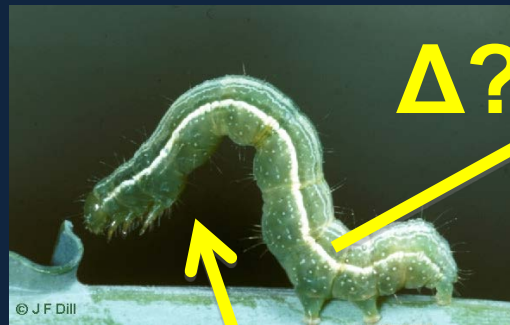


Remember this?

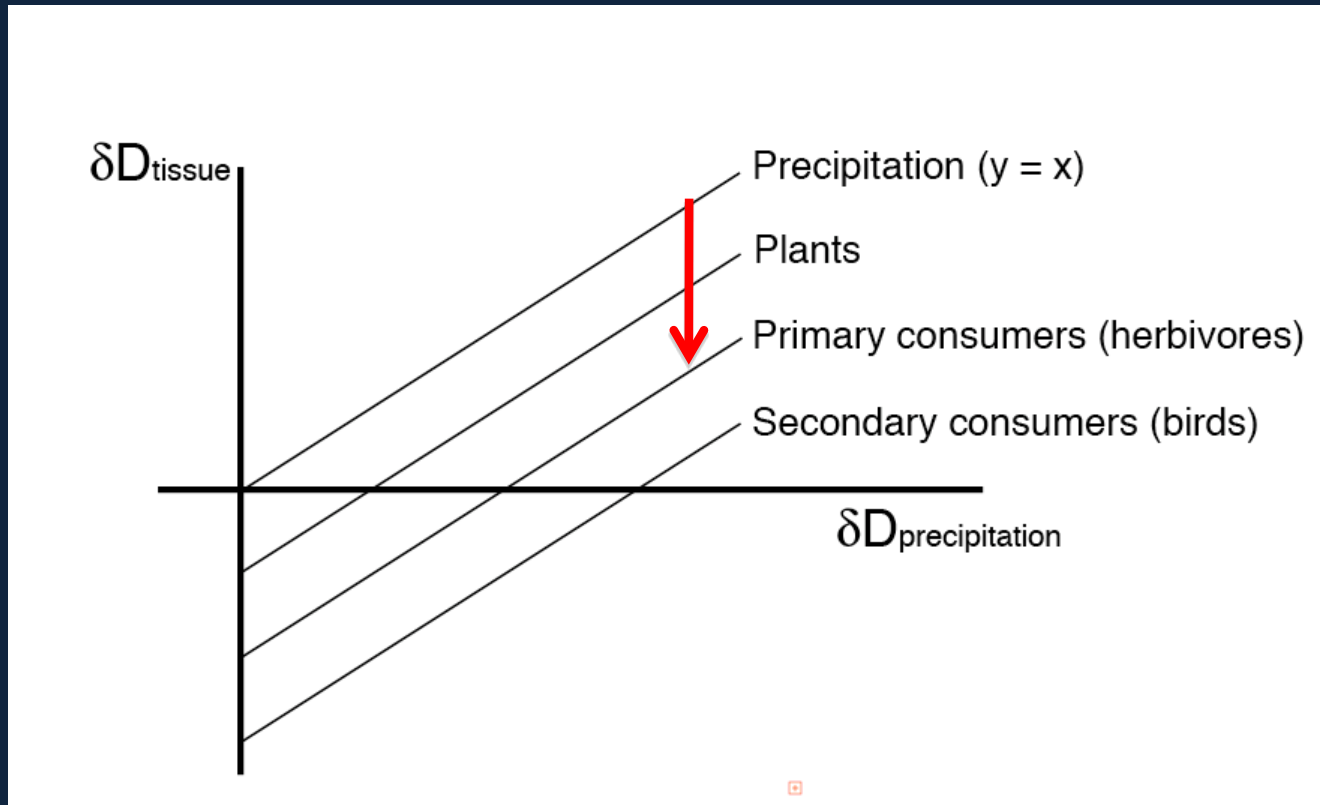


A better representation...

Three untested opportunities for change in δD value



My questions



My ultimate interests:

1. $\delta D_{\text{feather}} = \text{TMD}_{\text{precipitation}}?$
2. Do dD values change? Where?
3. Can this be used to limit the error?

Note: The discrimination effects are all depleting (the product less deuterium). Why is that?

The project design

	Treatment			
δD (‰)	-3.50	-48.7	-88.1	-130.6
Number of plants	5	5	5	5
Caterpillar/plant	5	5	5	5

Study System

- Cabbage Plants & Cabbage Loopers; *Brassica oleracea* and *Trichoplusia ni*:



The setup

D-enriched water (by adding 999AP D₂O)



Caterpillars

- Raised from egg



→
~ 4 weeks

→
~ 4 weeks

+ ~12 weeks for cabbage plants to grow to maturity

Quarantine strategy



Results (so far)

	Treatment			
δD (‰)	-3.50	-48.7	-88.1	-130.6
Number of plants	5	5	5	5
Caterpillar/treatment	30	24	22	23
Adults/treatment	5	7	5	8

To be done

- Water extraction by cryogenic distillation of:
soil, plants, caterpillars, adults
- Sample preparation (grinding,
homogenization, loading).
- Isotopic analyses at UW SIF

SIF



Why is this important?

- Management/conservation efforts for a given species are futile without an accurate knowledge of it's resource base
- Resource base intimately related to migratory patterns
- Our knowledge of these migratory patterns require accurate, reliable tracking methods
- I am curious...!!!

Unfortunately quantitative data is
pending...

But...

I have much observational data...

Science involves...

PATIENCE-SECOND EFFORT-FRUSTRATION-ANTICIPATION-ANXIETY-
UNCERTAINTY-AWE-ADDICTION-PRIDE-BROKEN PRIDE-EXHAUSTION
EXCITEMENT!!!

Nearly everything we “know” about nature is merely a model... Humans are itty bitty... I am itty bitty... My mind is as much a vulnerability as it is a weapon... Public speaking is tough... Books are not the authority... I have a tendency to disagree without reason... Sometimes I’m right... Scientists wives are busy.... I hope mine will love me anyway... There is no such thing as a closed system... Caffeine is habit-forming... Centrifuges have lids (fasten them!)... My best is not always good enough... Sometimes it is... Solidarity can be dangerous... Life is no highway... Sleep is important... Grades do not define me... Stuff costs money... There are ways to get money... A cell is not small... A lot can get done in 5 minutes... Not much can get done in a year... My strengths can be hindrances and my flaws, teaching tools... “Science is hard” ~Carlos and...

I LOVE IT!!!

Thank You

EPSCoR

Dr. Tim Collier

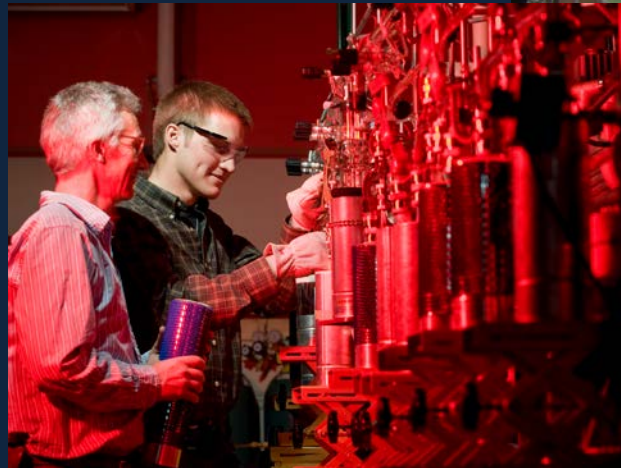
Nathan Wolf

Dr. Carlos Martinez del Rio

Dr. Seth Newsome

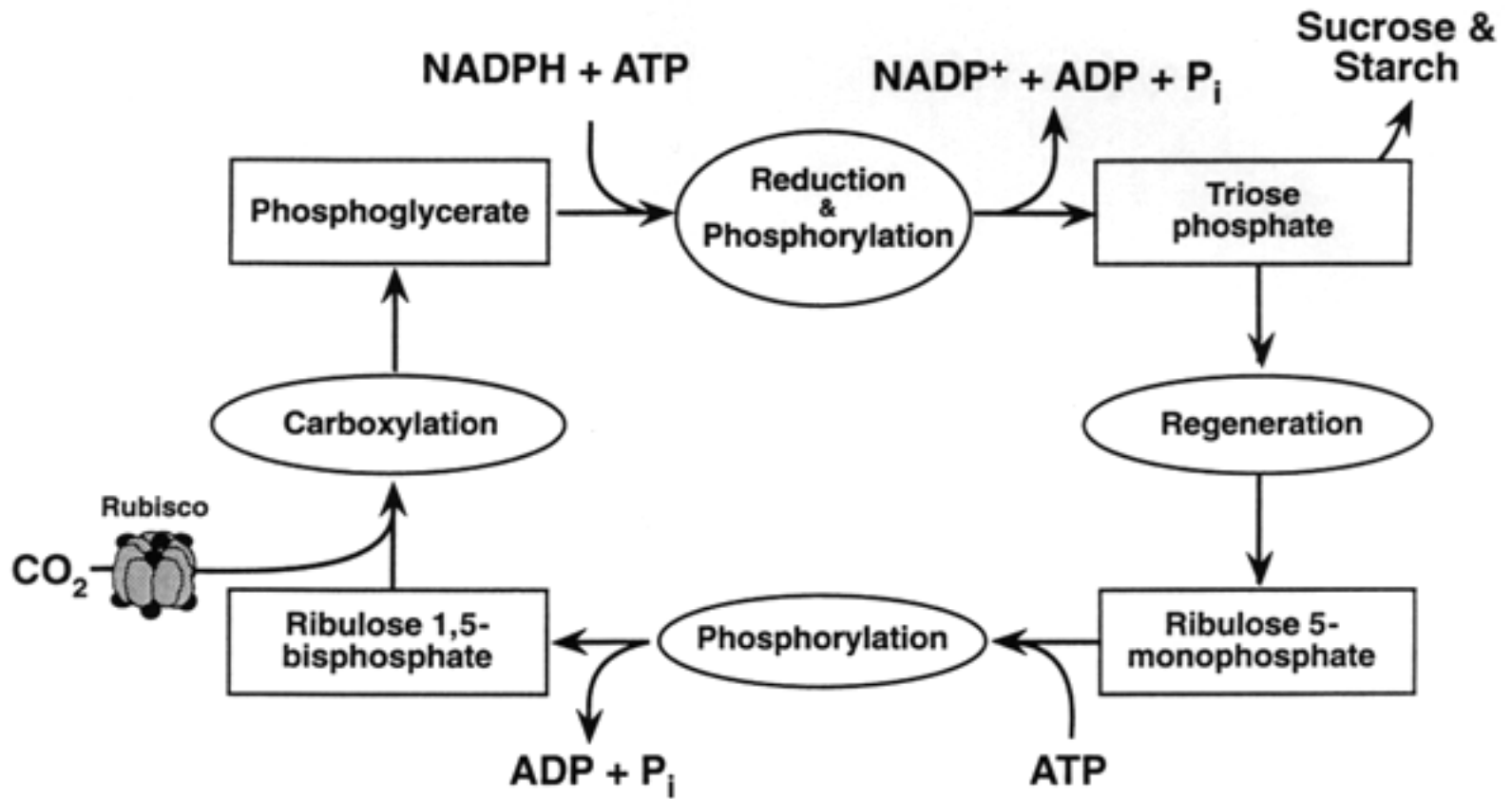
UW SIF

Questions?



Hypothetical causes of fractionation

- Evaporation due to decrease in vapor pressure with increasing mass (i.e., transpiration)
- Equilibria during synthesis?- may have preference for lighter isotopes (i.e., ?....
- Diffusion?- diffusion slows with increasing mass (i.e., ?.....
- What else Carlos?



Statistical analysis

- Estimation of Δ at each step by difference between intercepts (analysis of covariance)... Assuming that the relationships are linear (cross your fingers... If they are not I will borrow some books from Carlos)