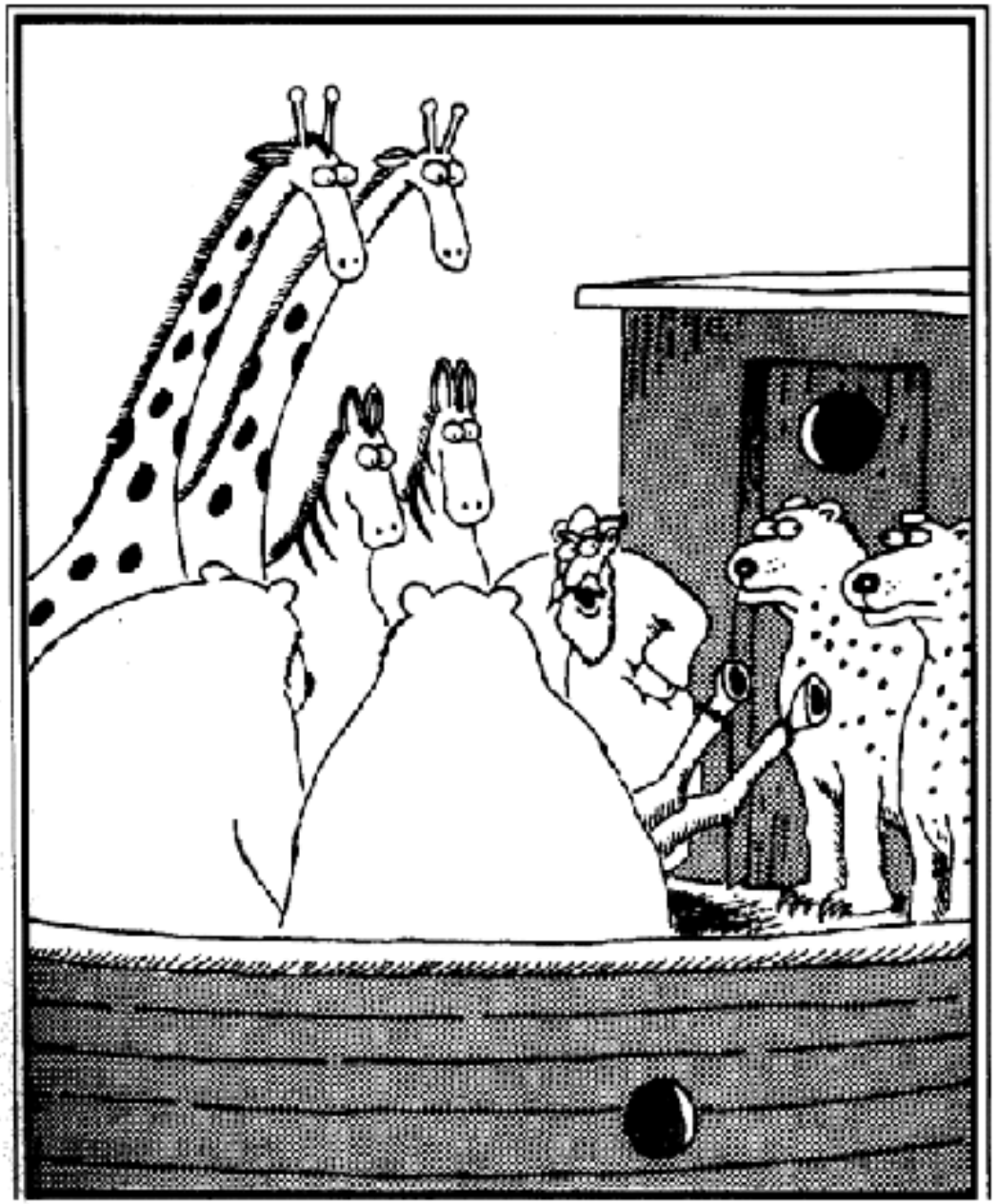
Foraging Behavior



"Well, so much for the unicorns . . . But from now on, all carnivores will be confined to 'C' deck."

Optimal foraging theory is an idea in _____ based on the study of _____ and states that _____ forage in such a way as to maximize their net _____ intake per unit time. In other words, they behave in such a way as to find, capture and consume _____ containing the most _____ while expending the _____ amount of time possible in doing so.

Profitability: Why eat only a subset of available prey

- Observation: Crows prefer large whelks and open them by dropping them from about 5 m
- Question: Is this **optimal** behavior?

1) Explain sexual habitat segregation within the scope of this paper.

2) Matching:

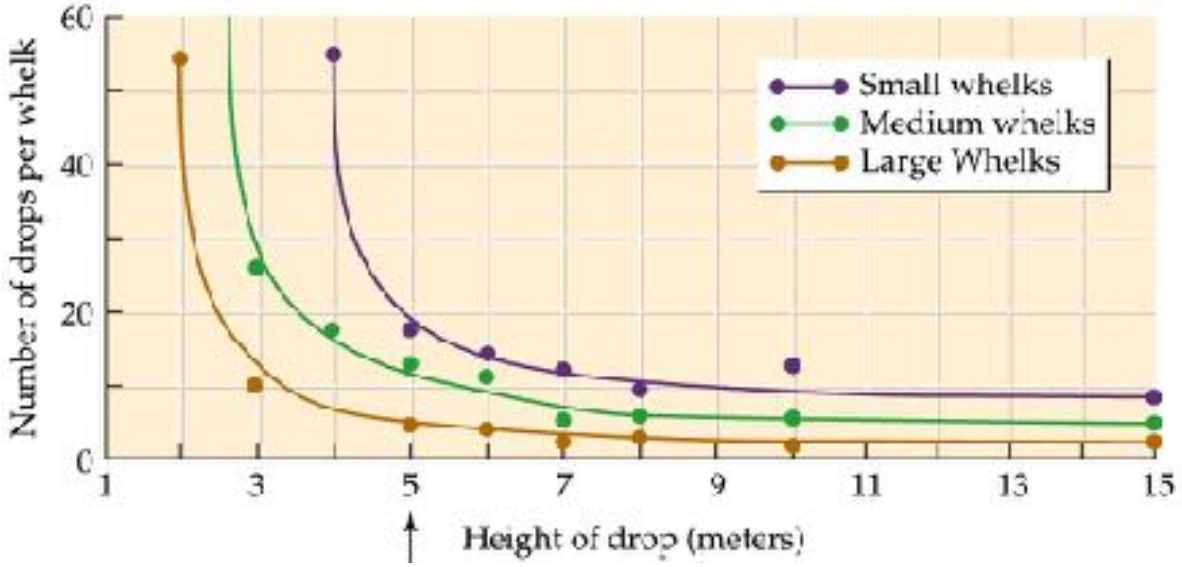
a) Overwinter persistence
b) Physical condition
c) Estimated longevity

1) Number of years following initial capture that individual redstarts returned to sites in each habitat
2) Rate at which color-banded red starts remained on territory from mid october to mid march
3) Years in which the redstarts lived after the researchers started their studies on them
4) Mass corrected for body size
5) Rate at which redstarts changed the color of their wings to account for the winter temperatures

3) What are 2 adaptive hypotheses that could explain sexual habitat segregation?

Profitability: Why eat only a subset of available prey

- Observation: Crows prefer large whelks and open them by dropping them from <u>about 5 m</u>
- Question: Is this **optimal** behavior?
- Test: Experimenters dropped whelks from various heights until they opened



  - Larger whelks required fewer drops than smaller ones
  - Drops > 5m did not improve probability of breakage for ea size

Profitability: Why eat only a subset of available prey

- Cost-benefit analysis on large whelks

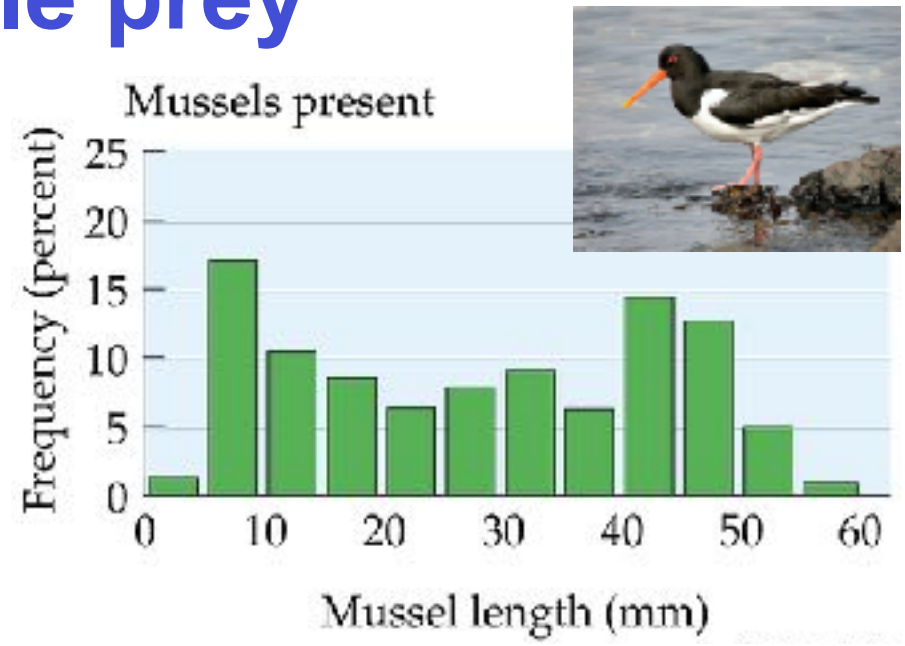
Height of drop (m)	Average number of drops required to break shell	Total flight height (m) (number of drops × height per drop)
2	55	110
3	13	39
5	6	30
7	5	35
15	4	60

Height that *minimizes* costs

= crows decision rule conforms to optimality theory

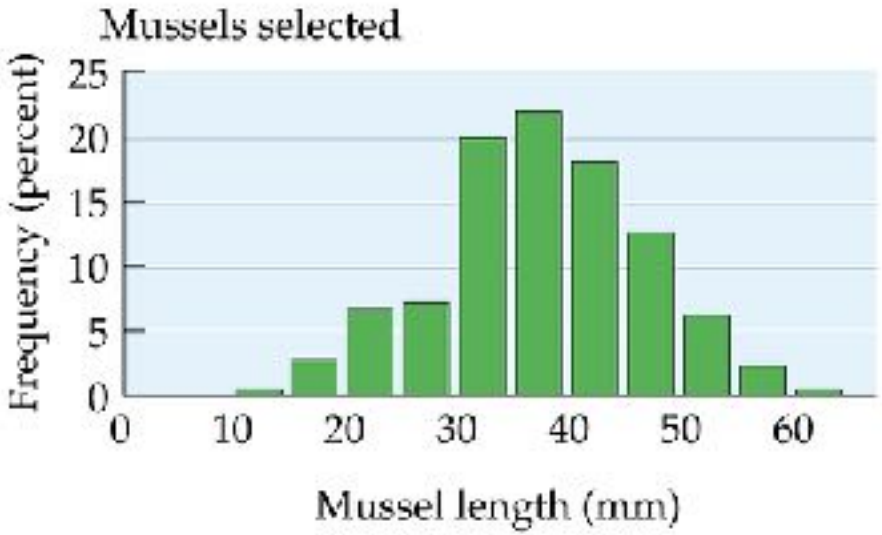
Profitability: Why eat only a subset of available prey

- Oystercatchers have many types of prey available
- Can their foraging decisions be modeled using optimality theory?

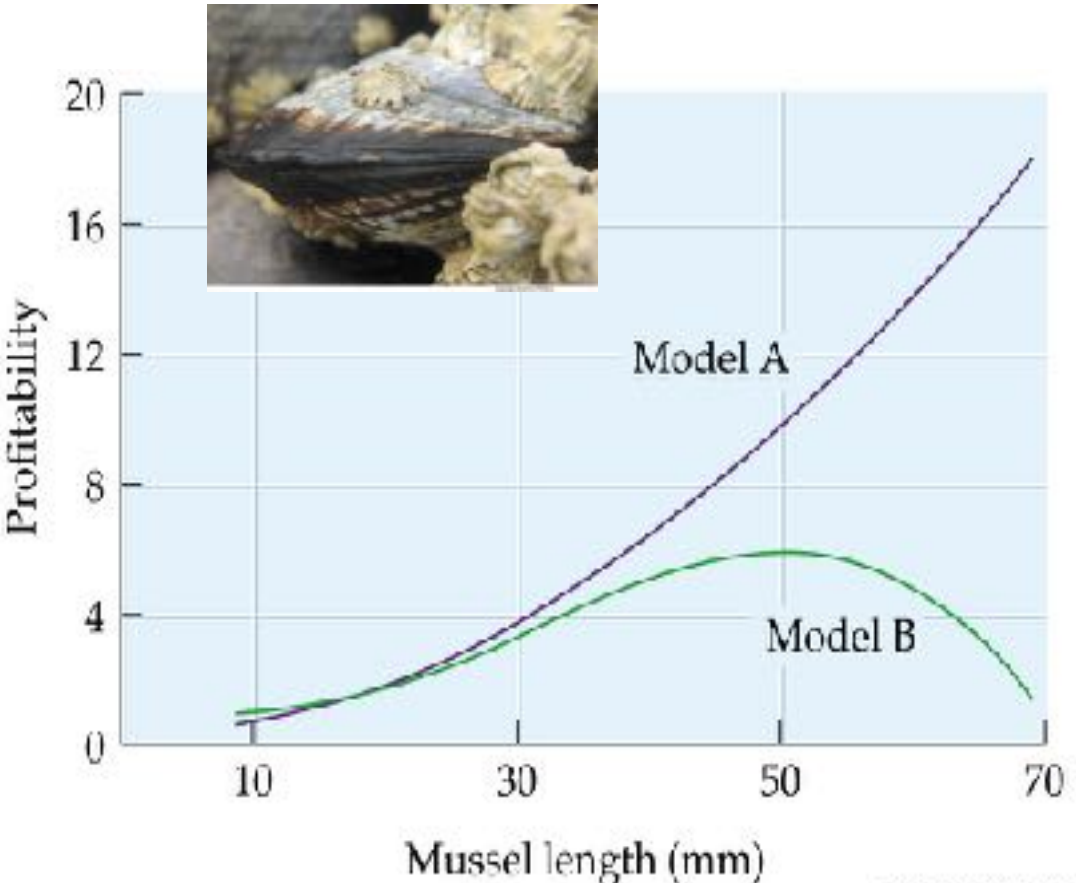


Profitability: Why eat only a subset of available prey

- Oystercatchers have many types of prey available
- Can their foraging decisions be modeled using optimality theory?
- They prefer 38mm mussels

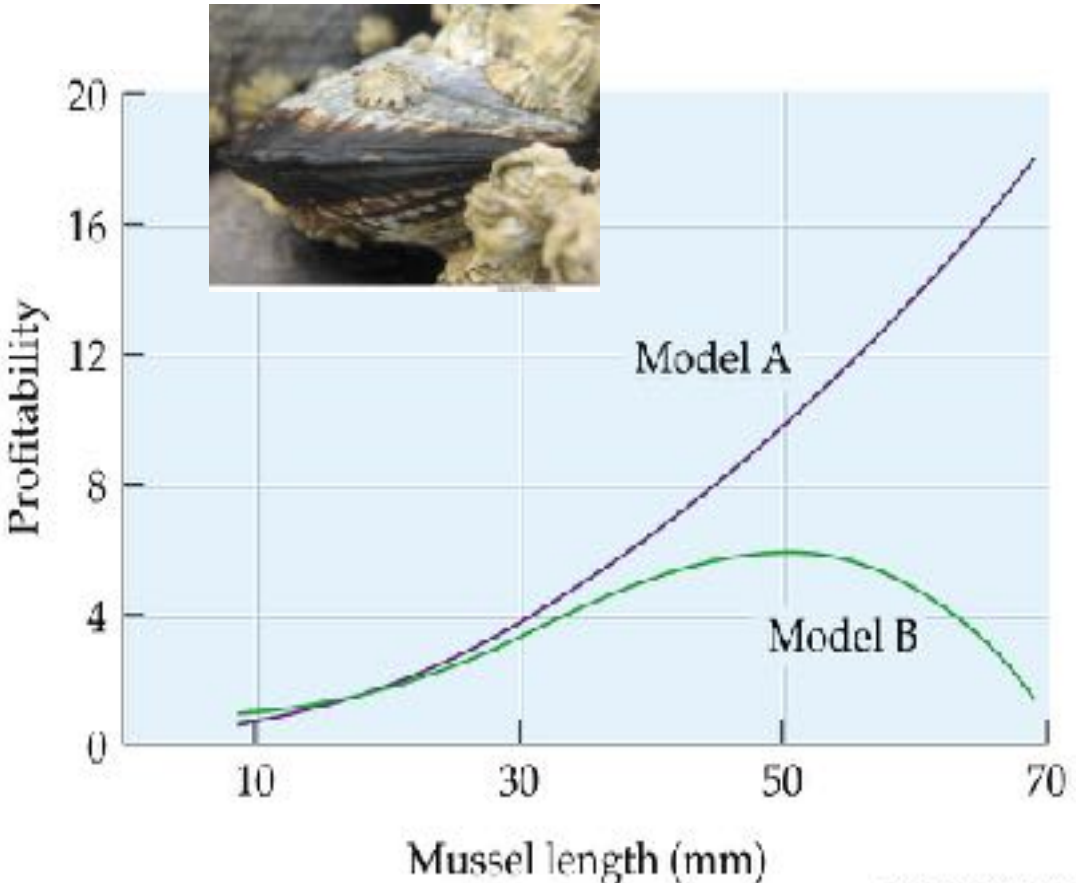


Profitability: Why eat only a subset of available prey



Model A: Assumes that food value relative to time/ effort is all that matters (incorrectly predict preference for far too large mussels)

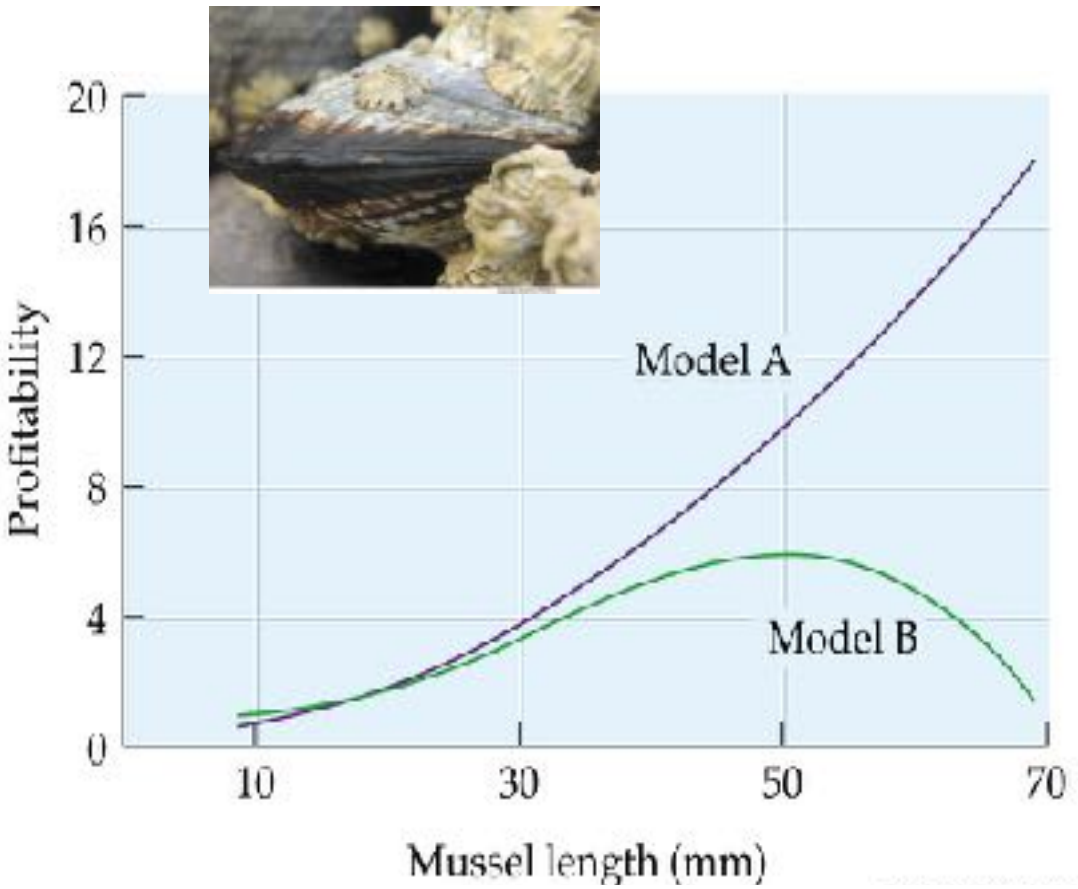
Profitability: Why eat only a subset of available prey



Model A: Assumes that food value relative to time/ effort is all that matters (incorrectly predict preference for far too large mussels)

Model B: Also factors in that some large mussels have to be abandoned (incorrectly predict preference for ~50mm mussels)

Profitability: Why eat only a subset of available prey



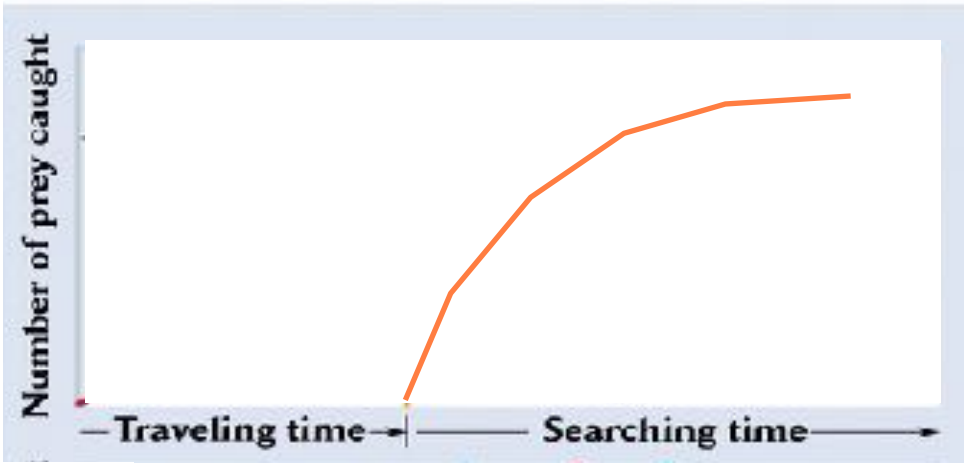
Model A: Assumes that food value relative to time/ effort is all that matters (incorrectly predict preference for far too large mussels)

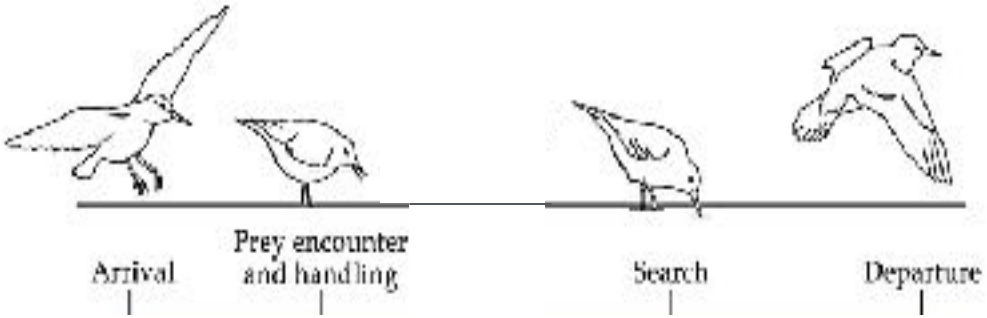
Model B: Also factors in that some large mussels have to be abandoned (incorrectly predict preference for ~50mm mussels)

Model C (not shown): Also factors in that barnacles on some larger mussels make them impossible to open (correctly predict preference for ~38mm mussels)

Behavioral flexibility when foraging: diminishing returns

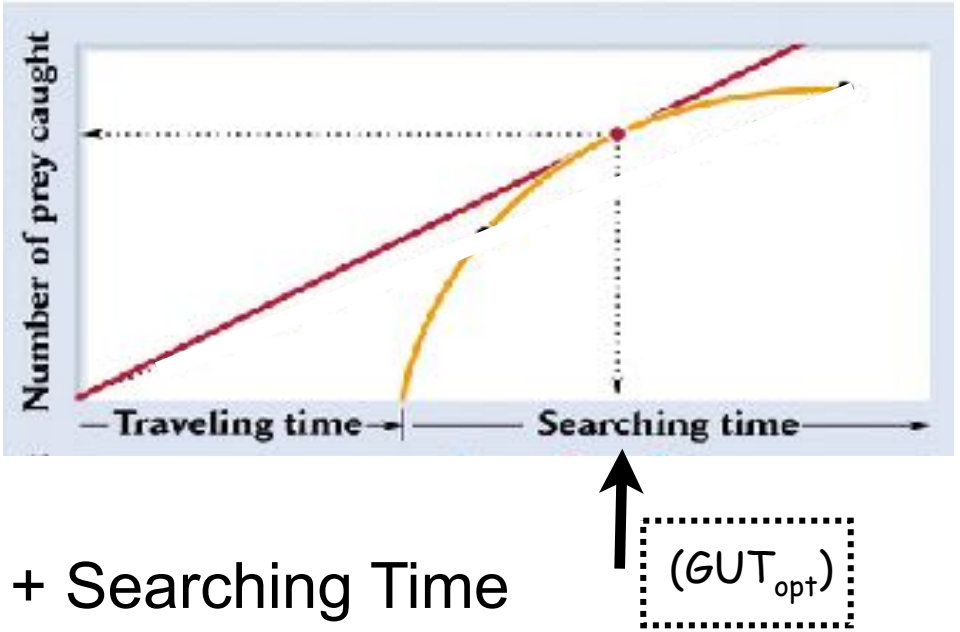
Optimal behavior:
Is there a point in time when an animal could do better by starting over in another patch?





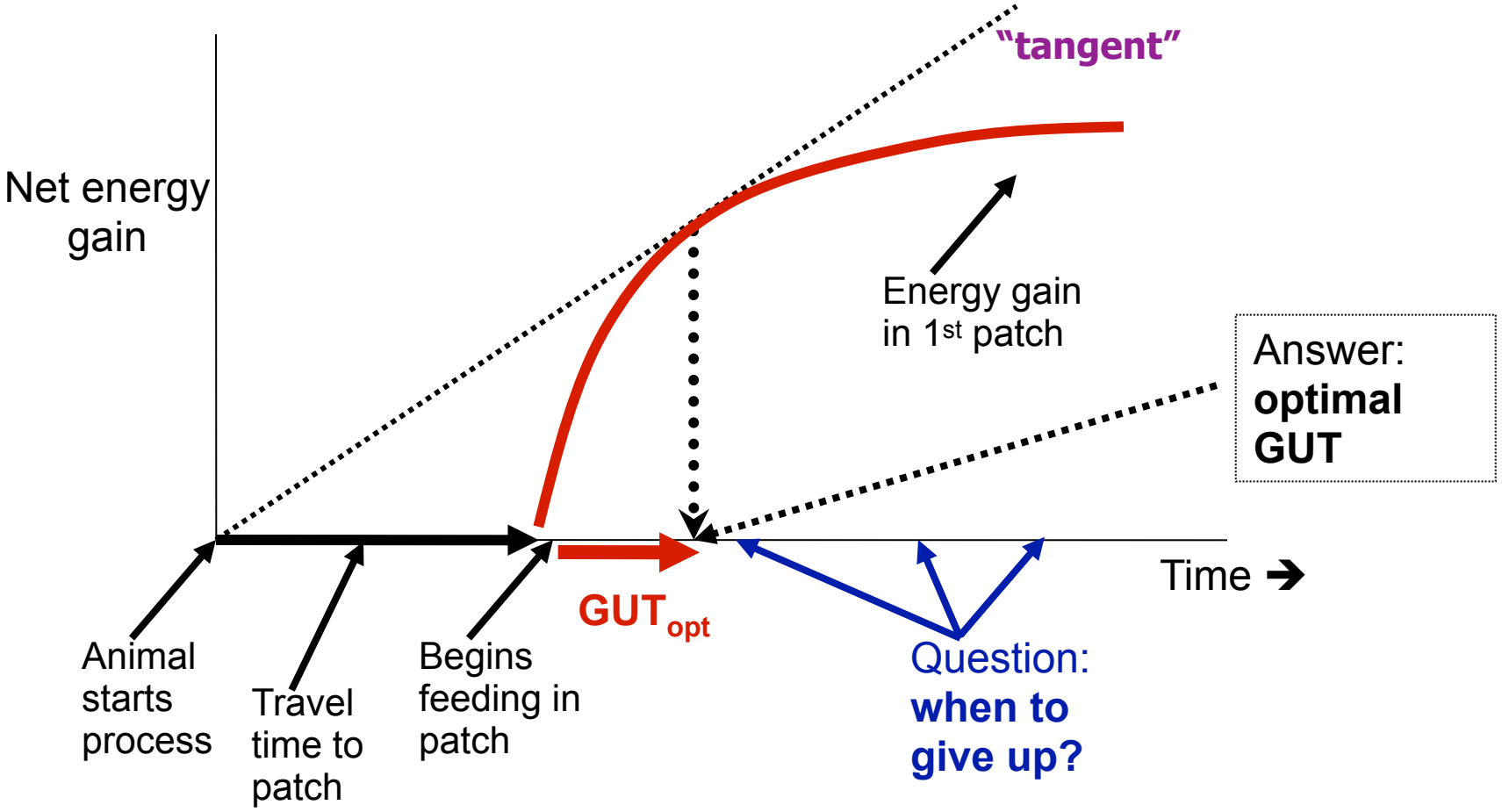
When is it optimal to find a new patch?

- Optimal Giving Up Time (GUT_{opt})
  - In model, organisms try to maximize energy intake per unit time

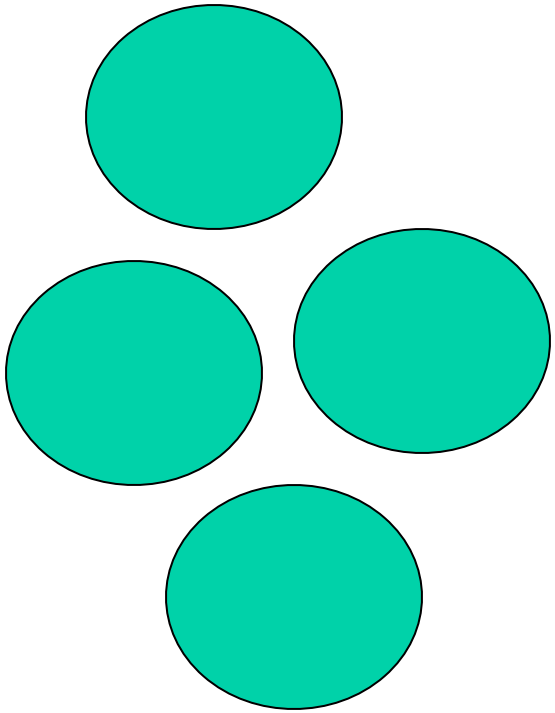


  - Components of model:
    - Total time = Travel time + Searching Time
      - Travel time reflects spacing between patches
      - Search time = foraging time (leads to diminishing returns)
  - Foraging efficiency = slope of line tangent to curve (from start of travel time). This line indicates the highest rate of delivery.
  - GUTopt: where tangent line intersects line of diminishing returns

GUT_{opt} model: how does it work?

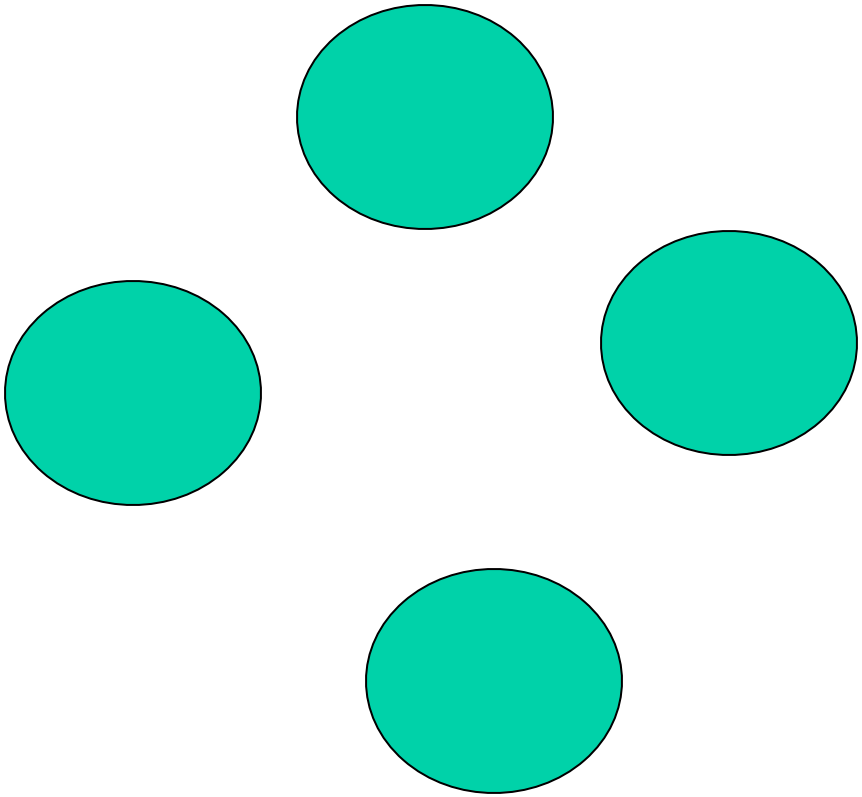


What if the *spacing* of patches differs?



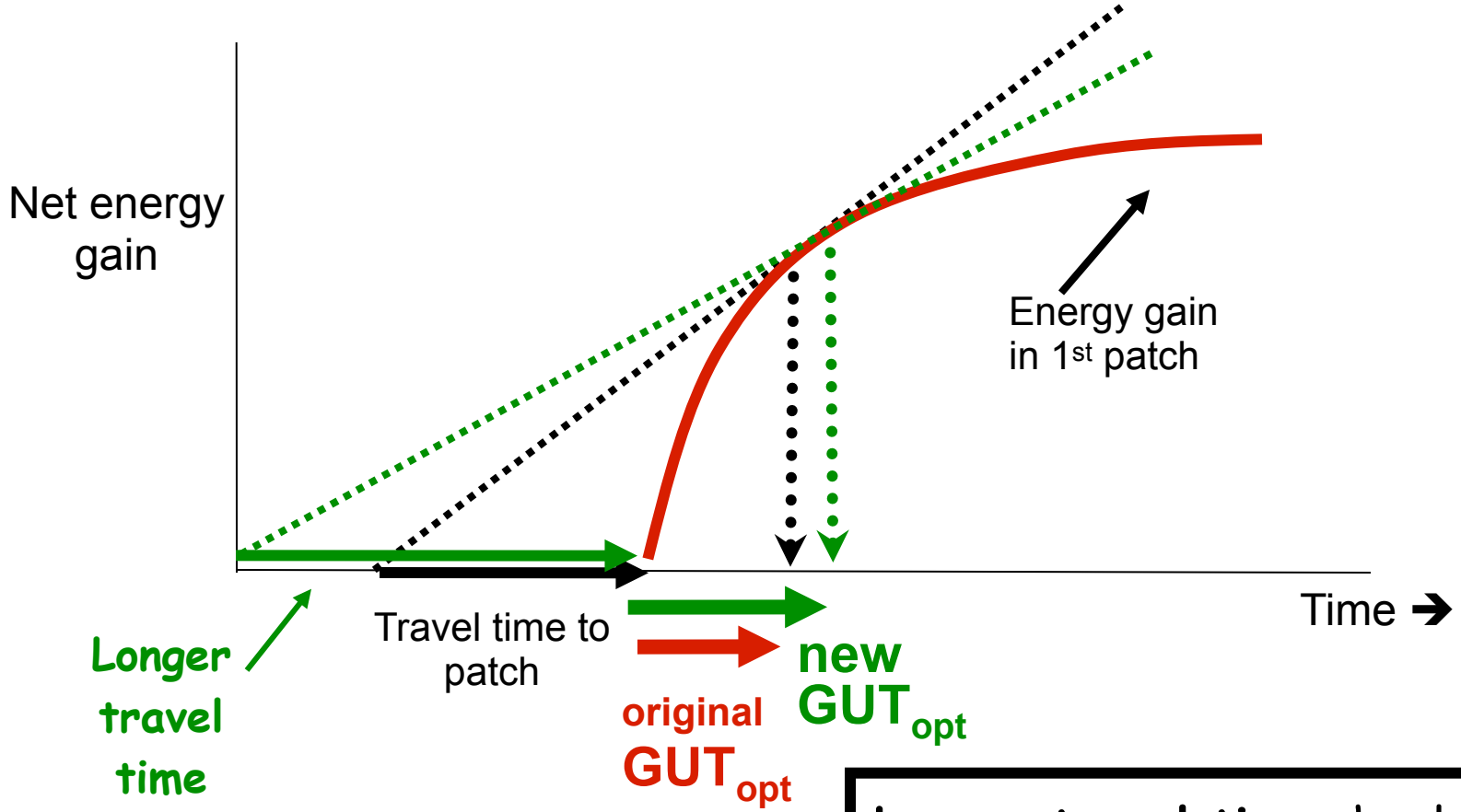
Set of patches close together

vs.



Set of patches farther apart

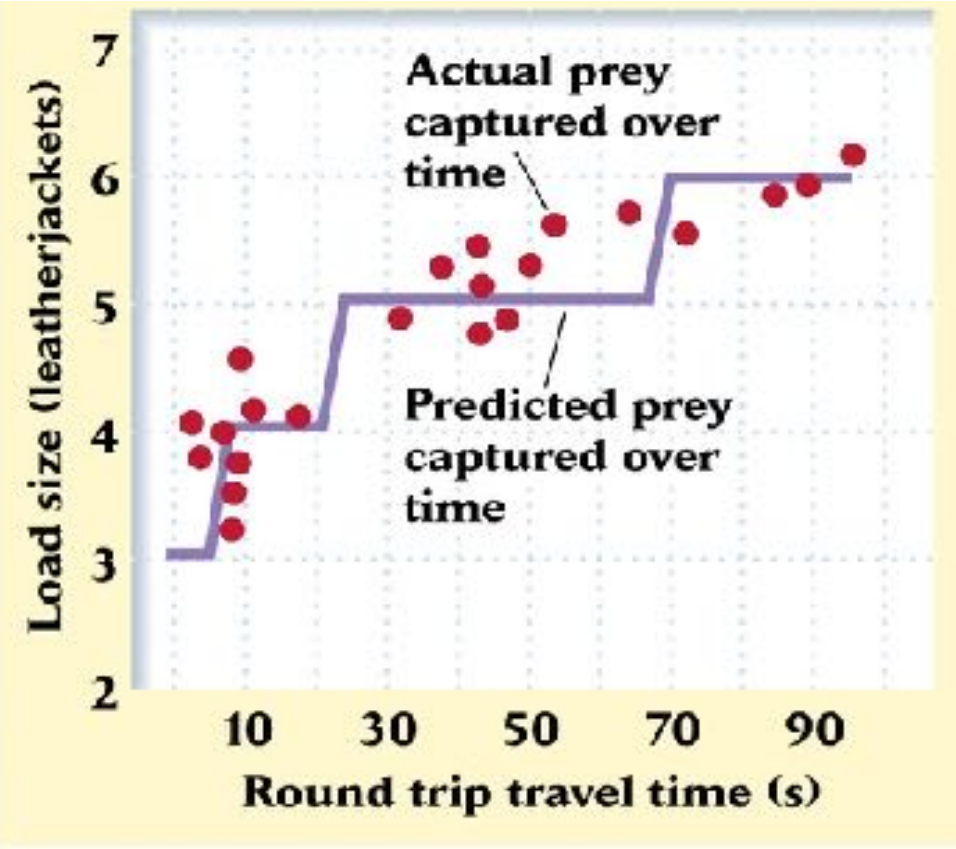
What if the *spacing* of patches differs?



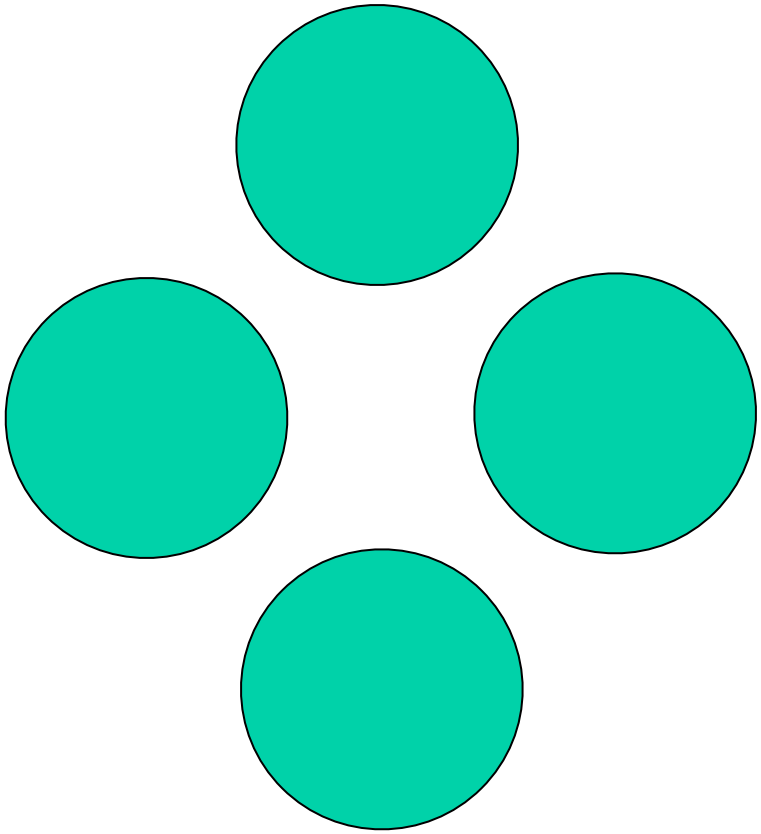
Longer travel time should result in longer time in patch

GUT_{opt} applied to real-world

- Starlings forage for larger loads when patches are distant!

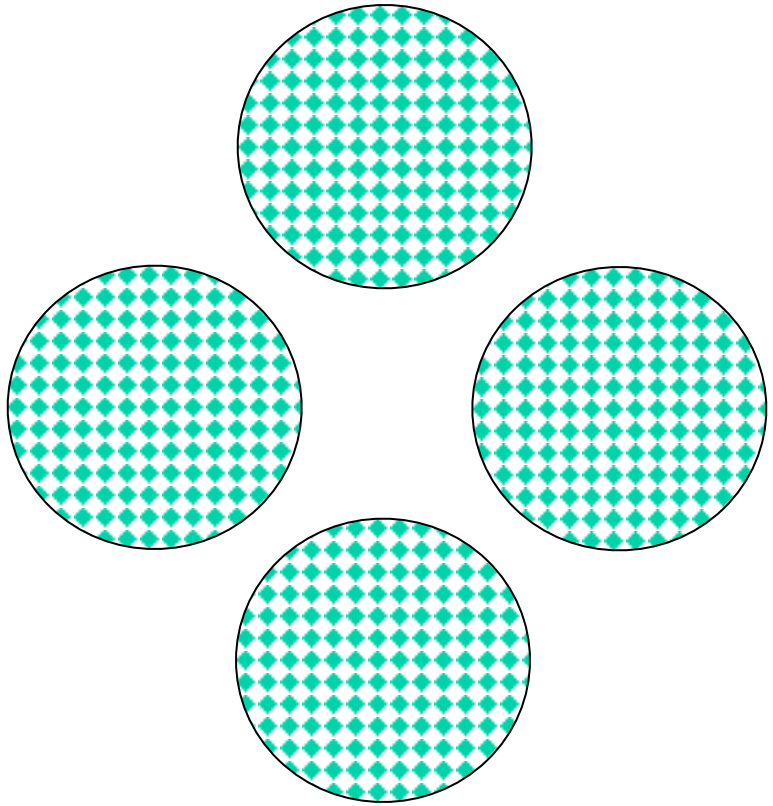


What if the *quality* of patches differs?



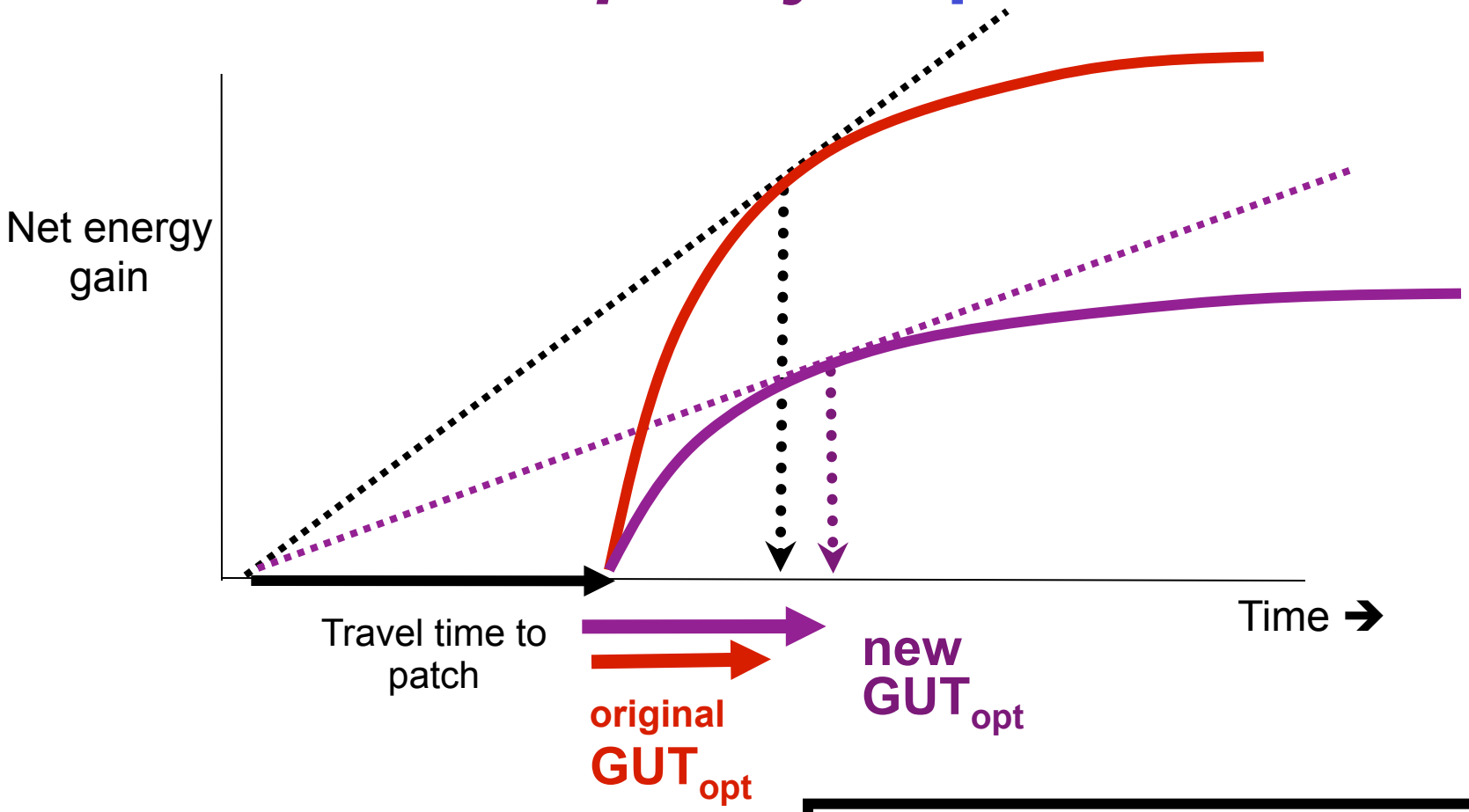
Set of equidistant high-quality patches

vs.



Set of equidistant low-quality patches

What if the *quality* of patches differs?

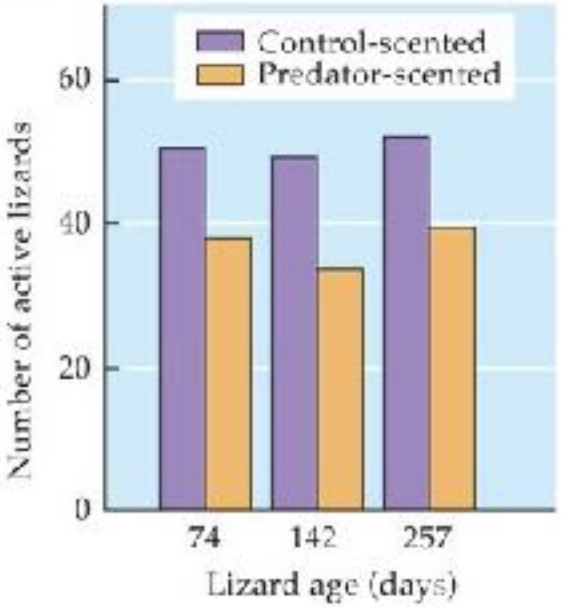


Poorer quality patches should result in longer time in patch

Predation tradeoffs

- Other considerations affect optimality, like the probability of being eaten
  - Skinks forage more cautiously in snake-scented areas

(A)

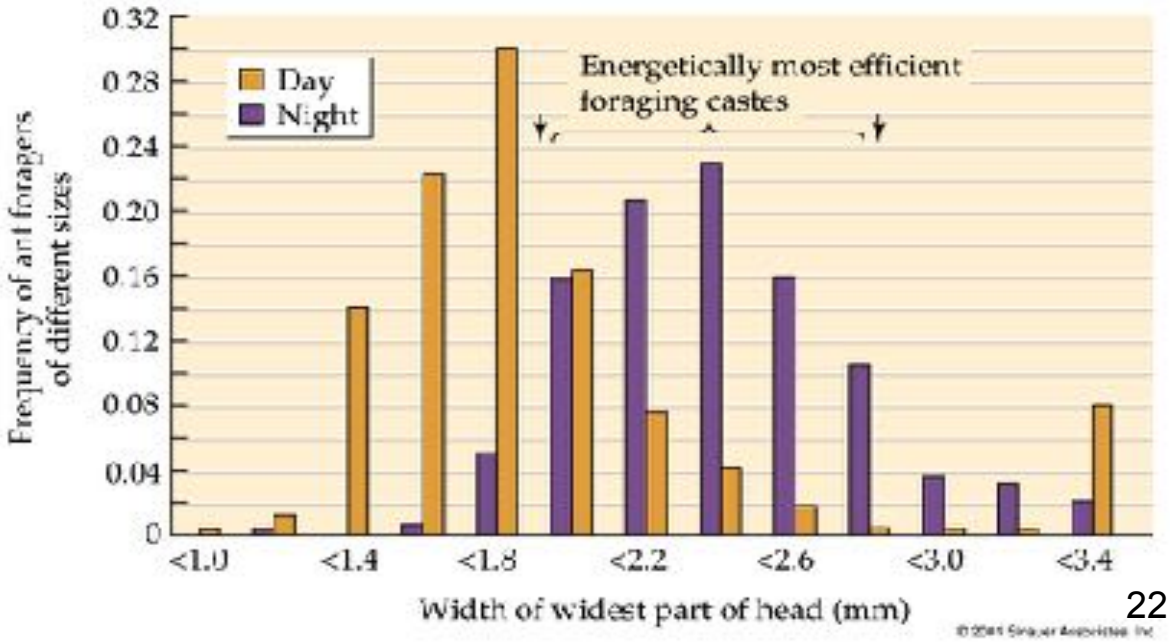


Tradeoff = foraging success vs. predation risk

Predation (parasitism) tradeoffs

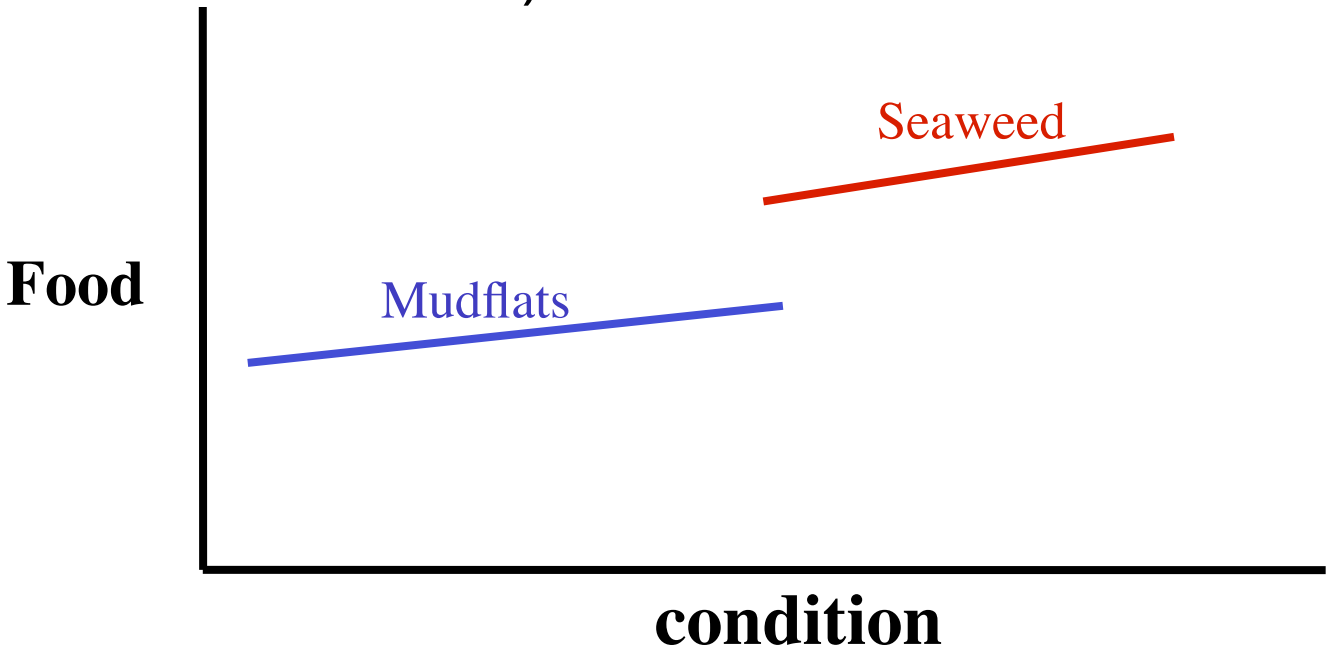
Leaf cutter ants

- Larger ants would do a better job at foraging for colony...but if they try during the day, they are parasitized



Optimality Theory:

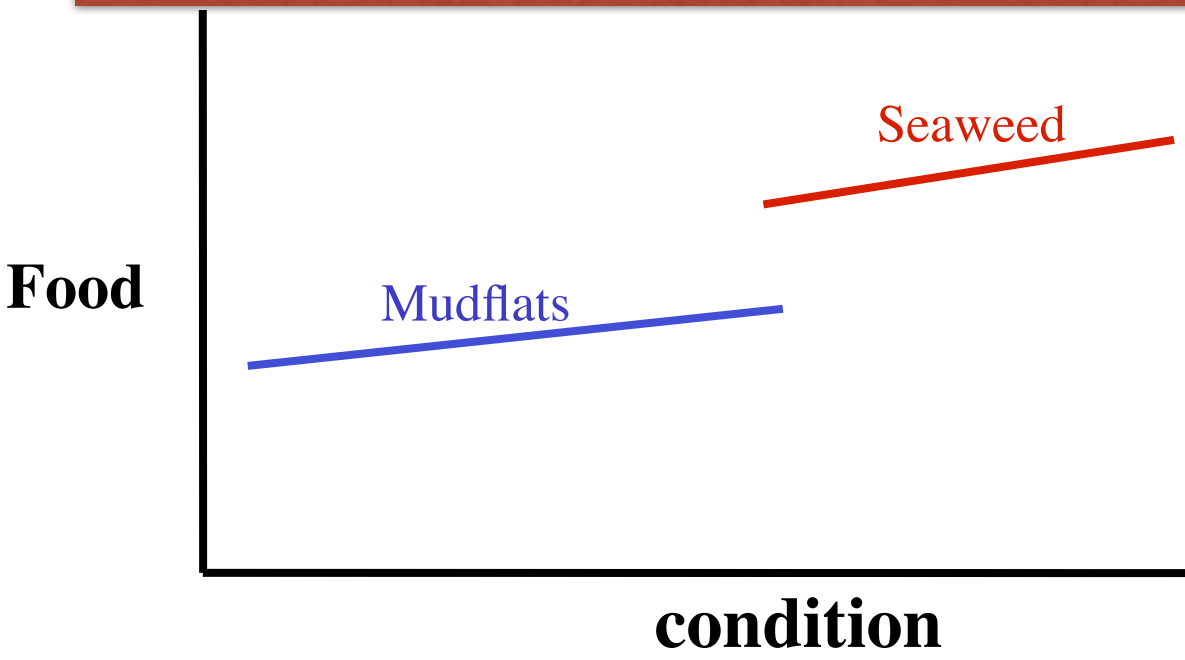
- Conditional response
  - Optimal foraging tactic may vary depending on individual condition
    - ex. high and low condition birds forage in different areas (takes more energy to forage in seaweed)



Optimality Theory:

- C

Optimality modeling is too simple when there are social interactions to consider



Game Theory: What are competitors doing?

- Optimality models sometimes too simplistic
  - Foraging efficiency may depend on what others are doing
    - ex
      - Two foraging tactics: Can hunt your own food, or can steal from others

Game Theory: What are competitors doing?

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      - Two foraging tactics: Can hunt your own food, or can steal from others
      - But what happens if stealing becomes common?

Frequency independent payoff

- I'll give you $2 if your hand is up, and $1 if your hand is down

Frequency independent payoff

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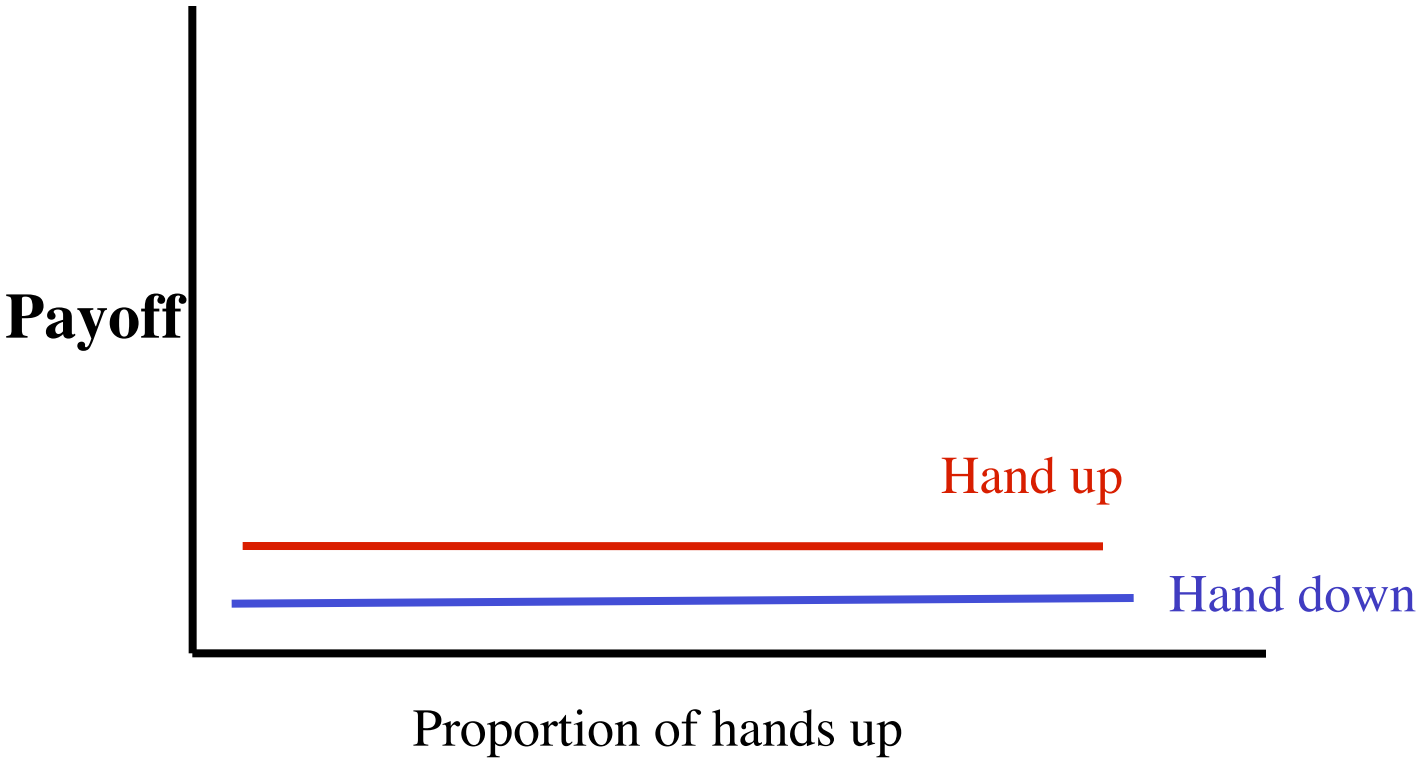

Negative frequency dependence

Negative frequency dependence

- If hand up, get $1 for every hand in class that is down

Negative frequency dependence

- If hand up, get $1 for every hand in class that is down
- If hand down, get $2 for every hand in class that is up

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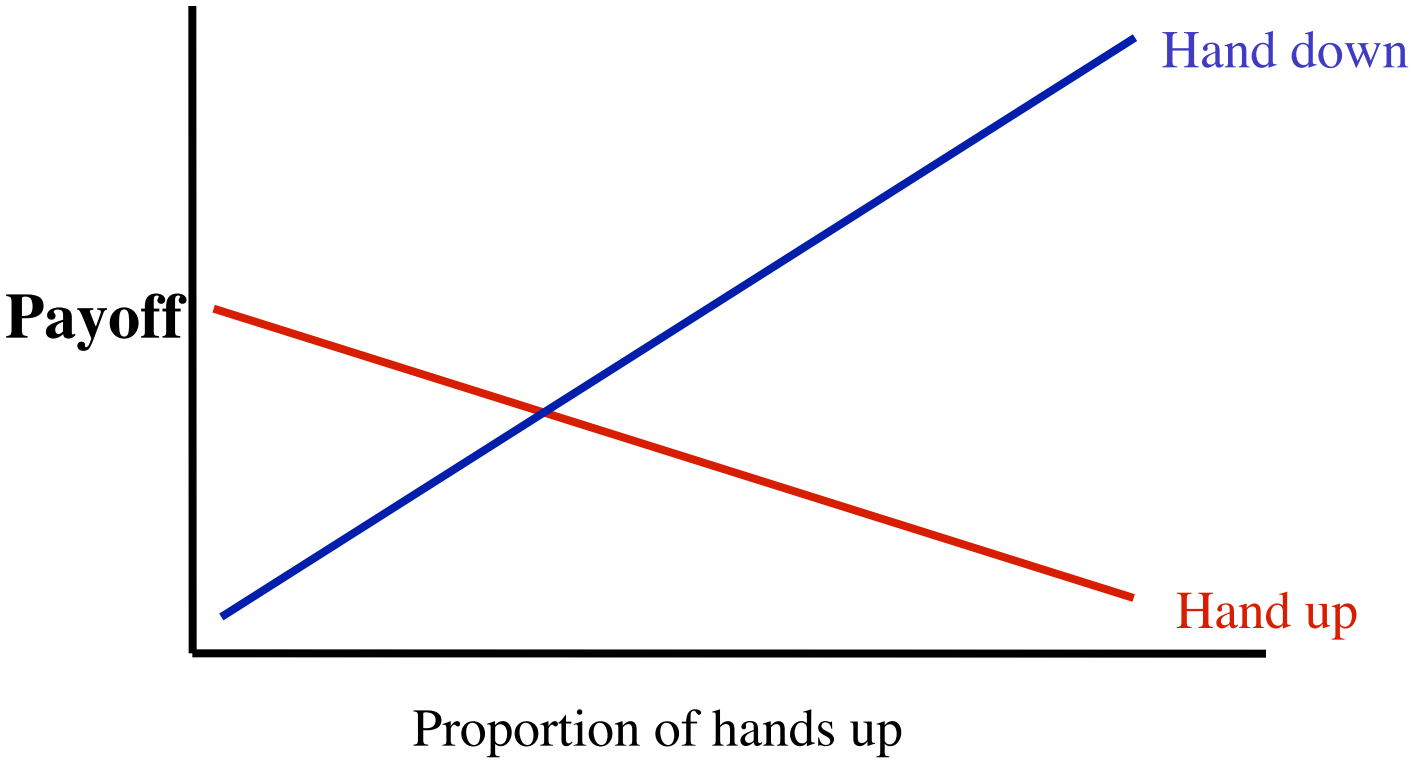

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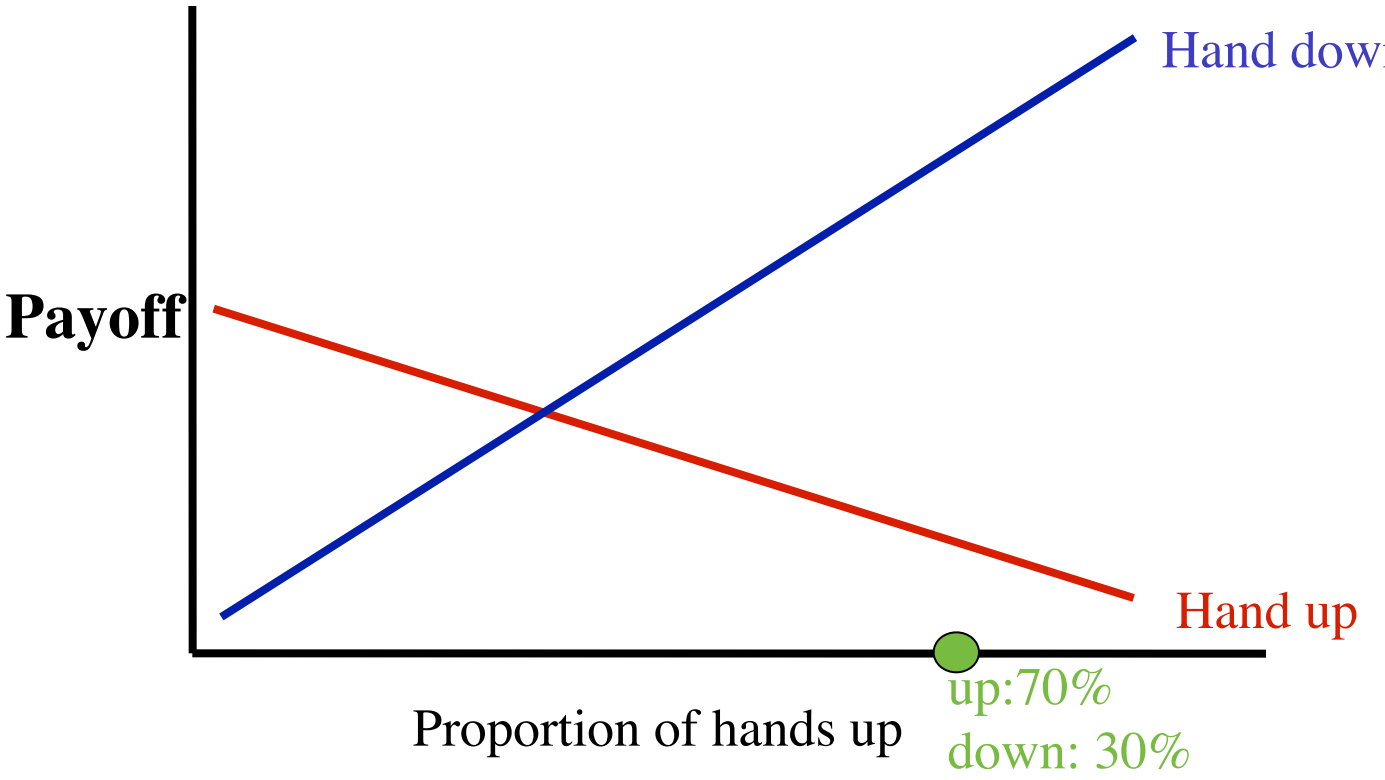

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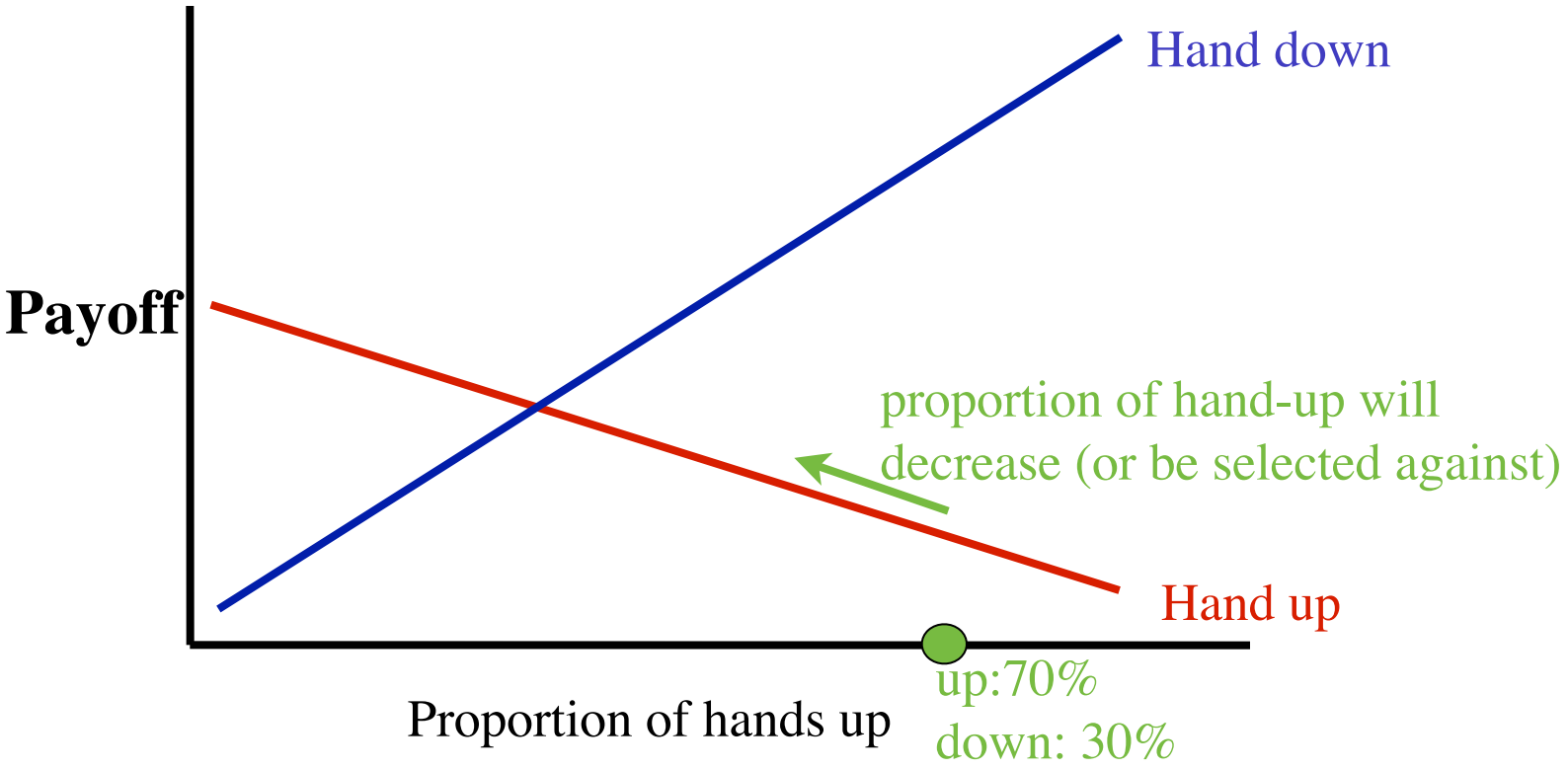
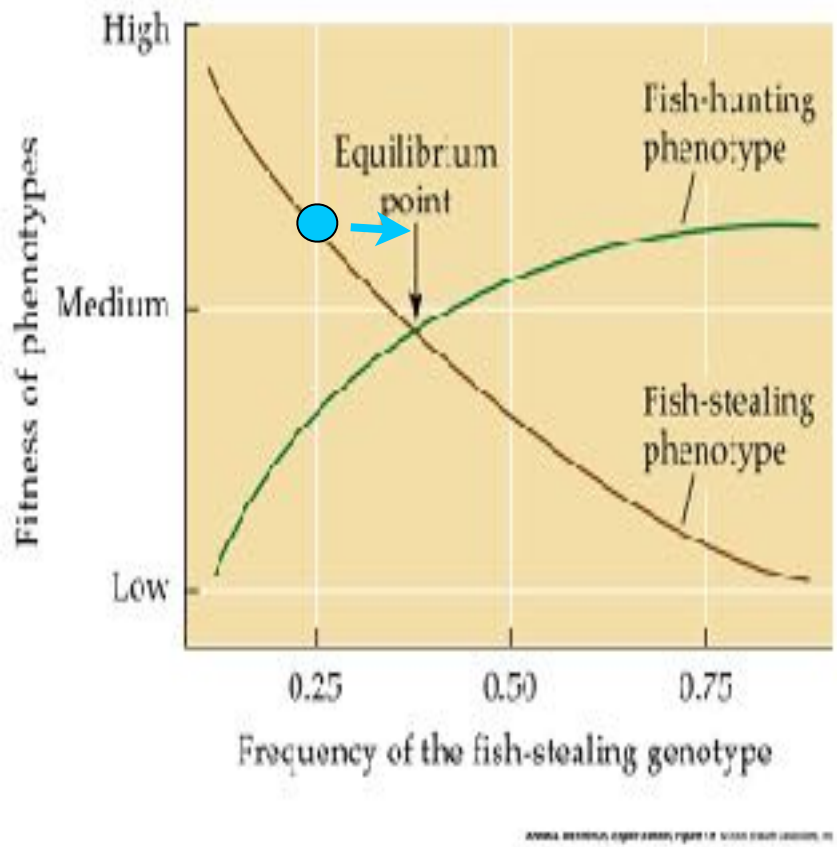


Negative frequency dependence

- Payoff of stealing tactic depends on its frequency
  - What happens when:
    - 25% stealers
      - stealers do well & population moves towards more stealers (and less hunters)



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    - 50% stealers
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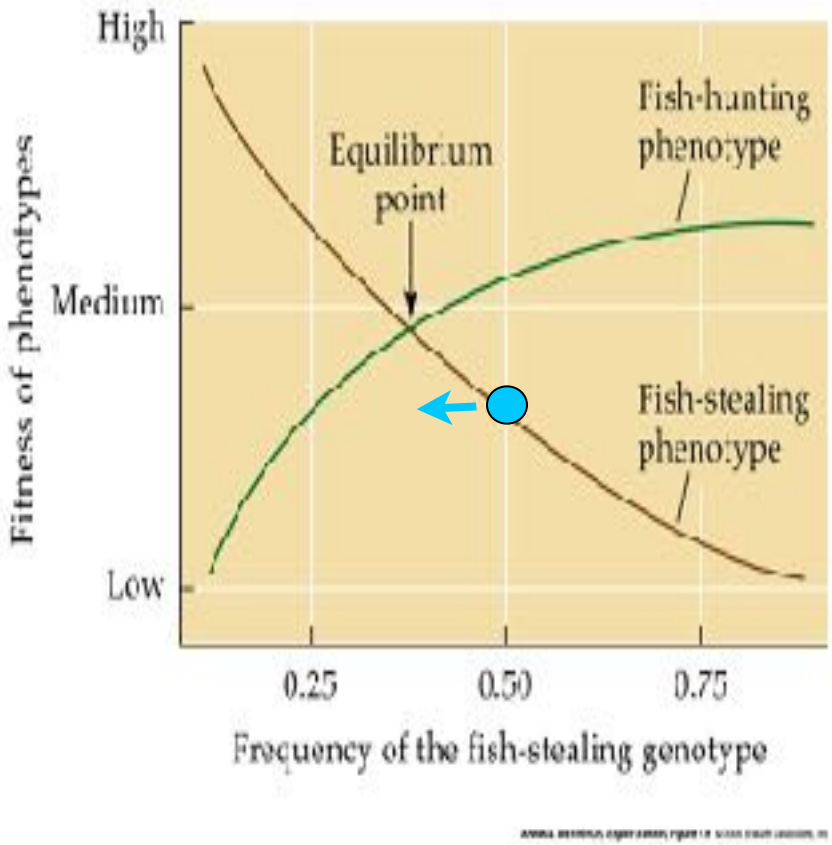

Negative frequency dependence

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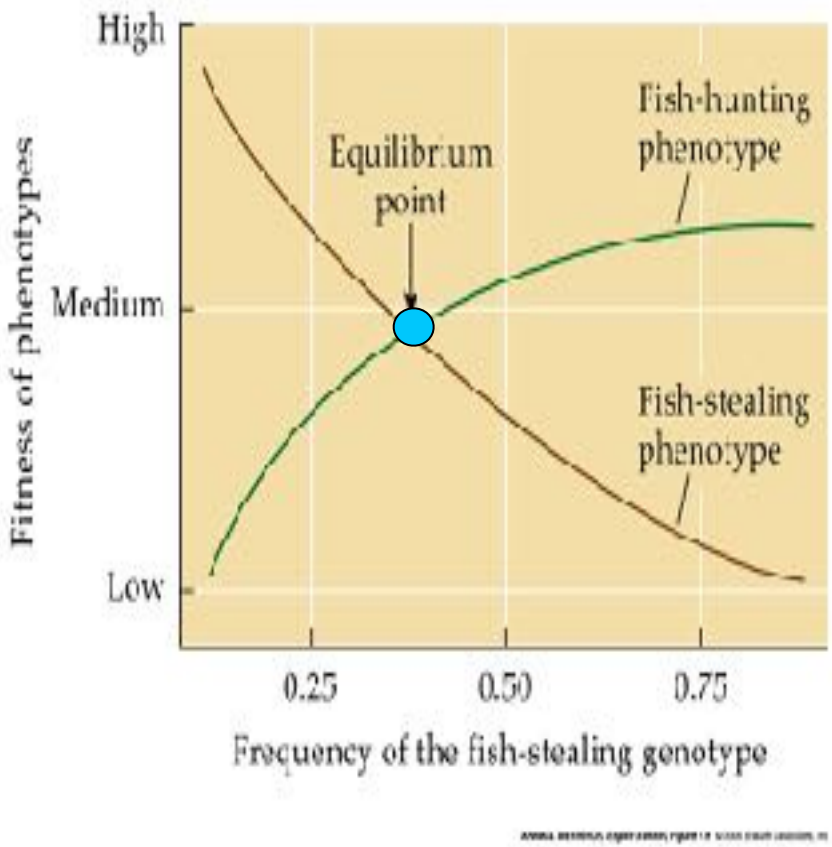
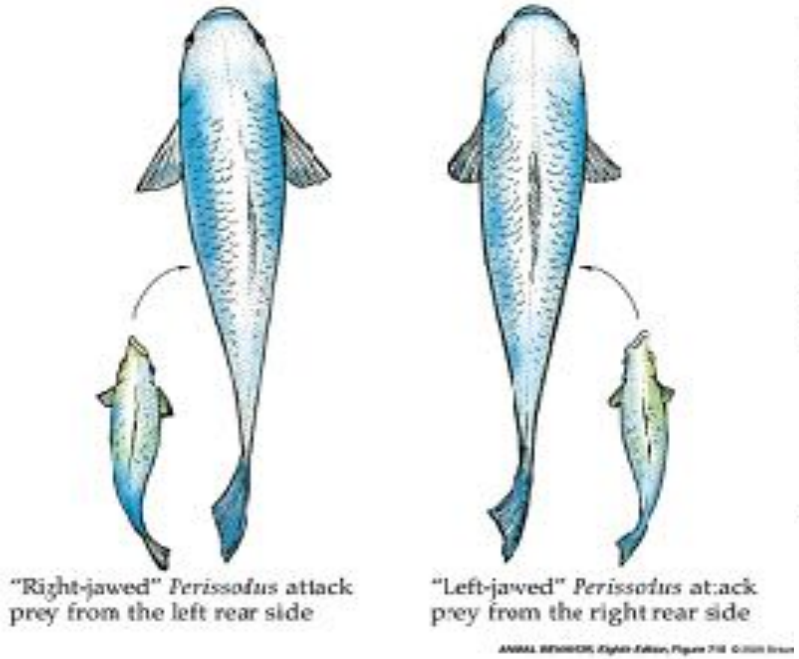
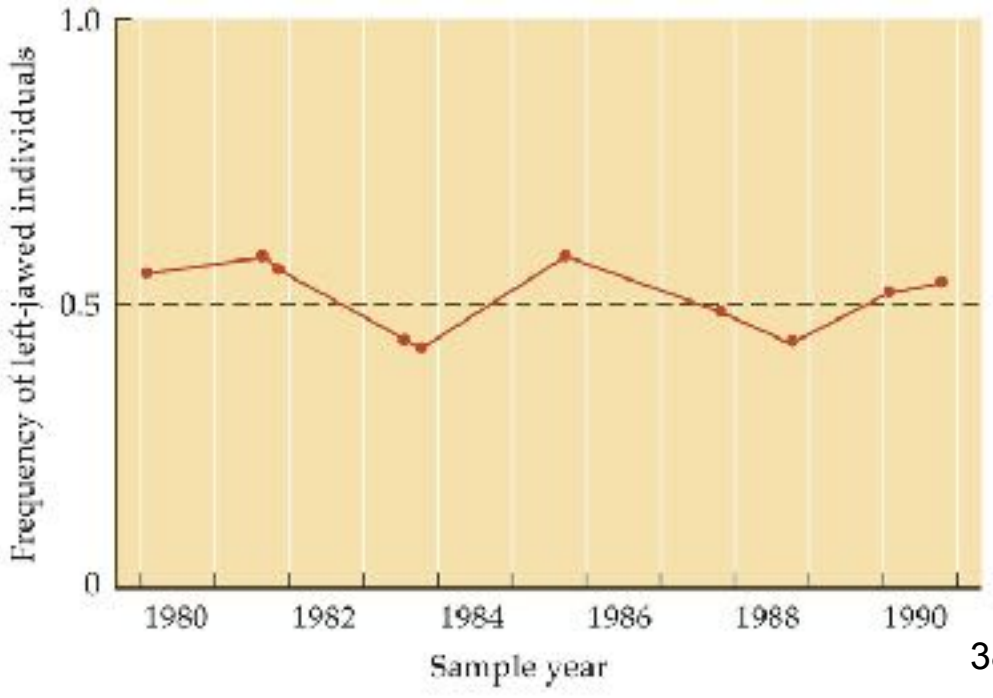
    - 50% stealers
      - stealers do poor & population moves towards less stealers (and more hunters)
    - 37% stealers
      - both types do equally well and population is at equilibrium



Negative frequency dependence

- Frequency-dependent morphs
  - Scale eaters
    - Costs of being common type is that bigger fish learns what side to protect and eats scale-eater
      - population fluctuates around 50:50





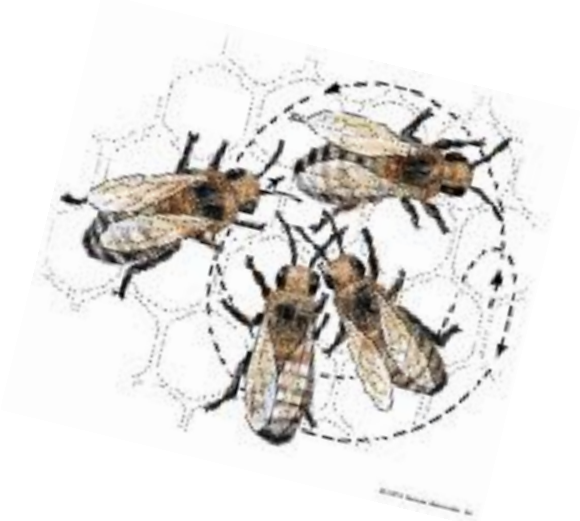
Negative frequency dependence

Male vs Female

Sophisticated foraging:
The transfer of information in "like-minded" honeybees

- Honeybee workers are all sisters, and queen is their mother
- All have shared interest in success of the hive … because it contains multiple relatives
  - their own genes spread when mom reproduces

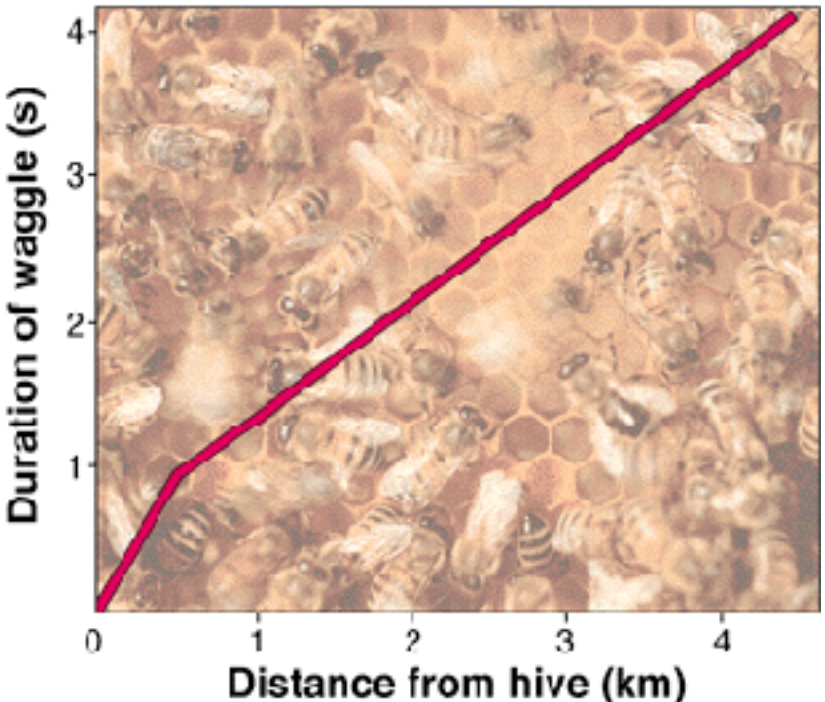
Types of honeybee dances



Round Dance

< 50M from hive

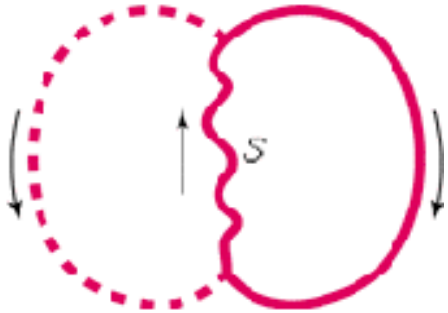
no directionality



Waggle Dance

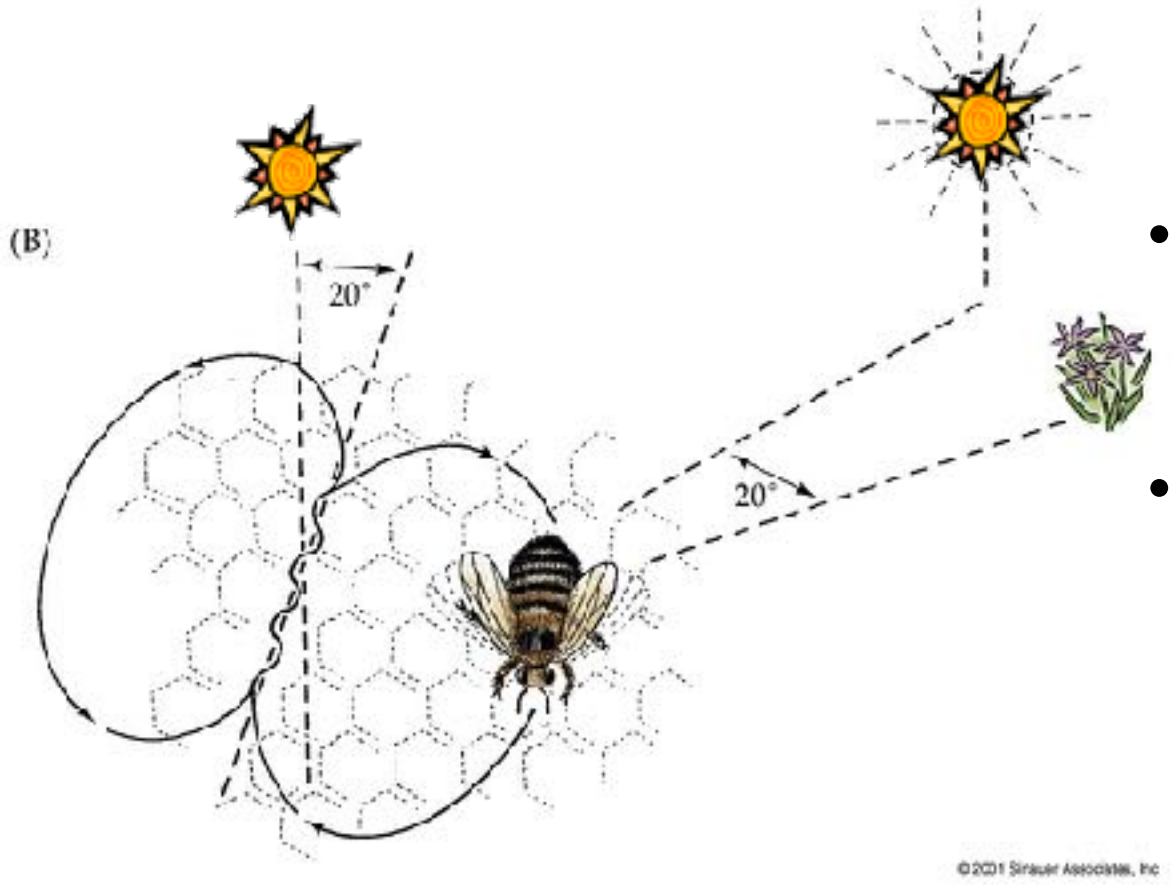
Specific information:

distance & direction



Honeybee dance language

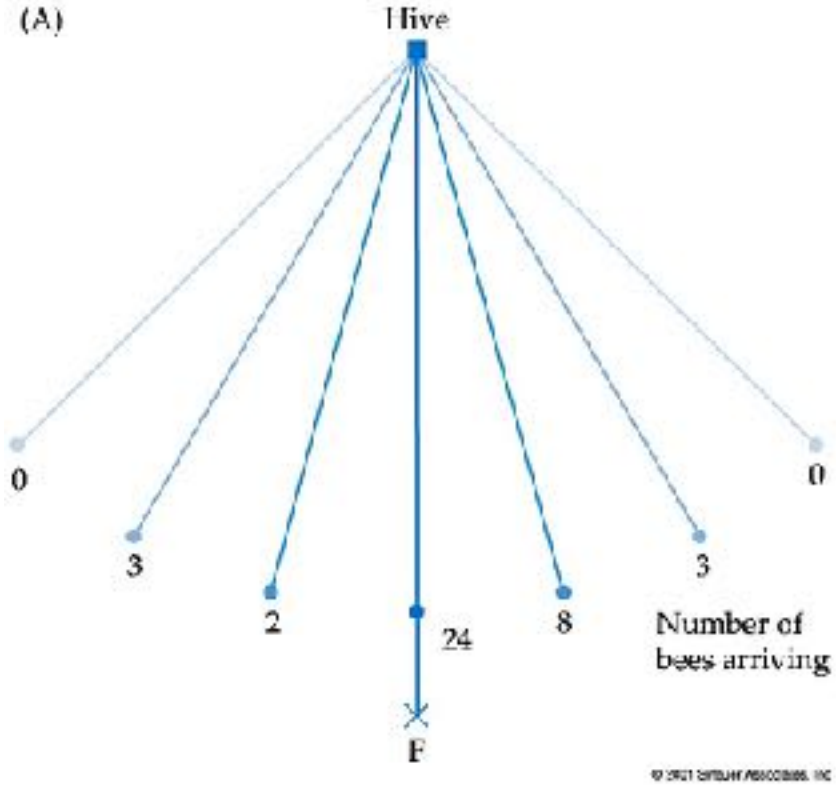
- Waggle dance conveys distance and direction

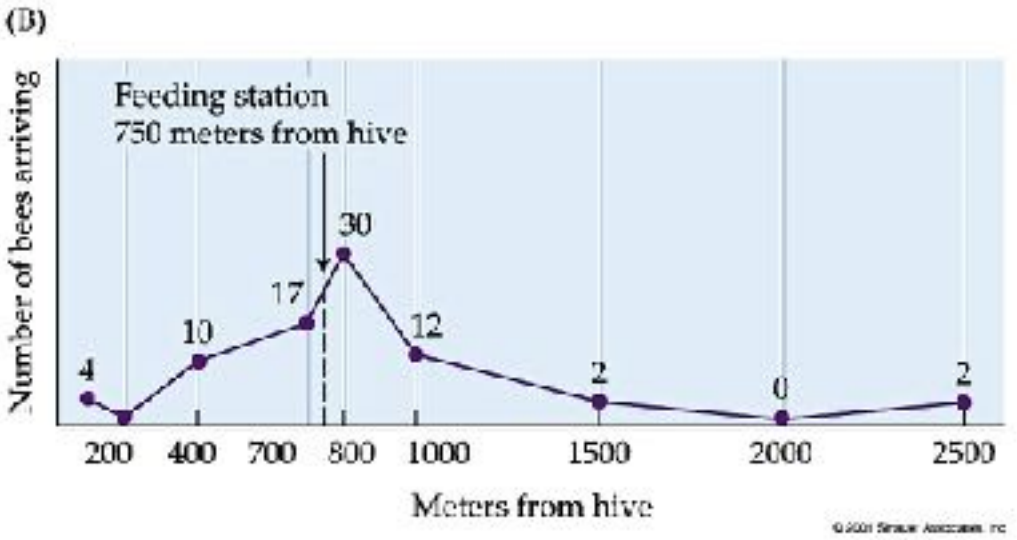


- **Length** of waggle indicates **distance**
- **Angle** of dance (compared to straight-up in hive) indicates **direction** to food relative to sun

Test of information encoded in the waggle dance

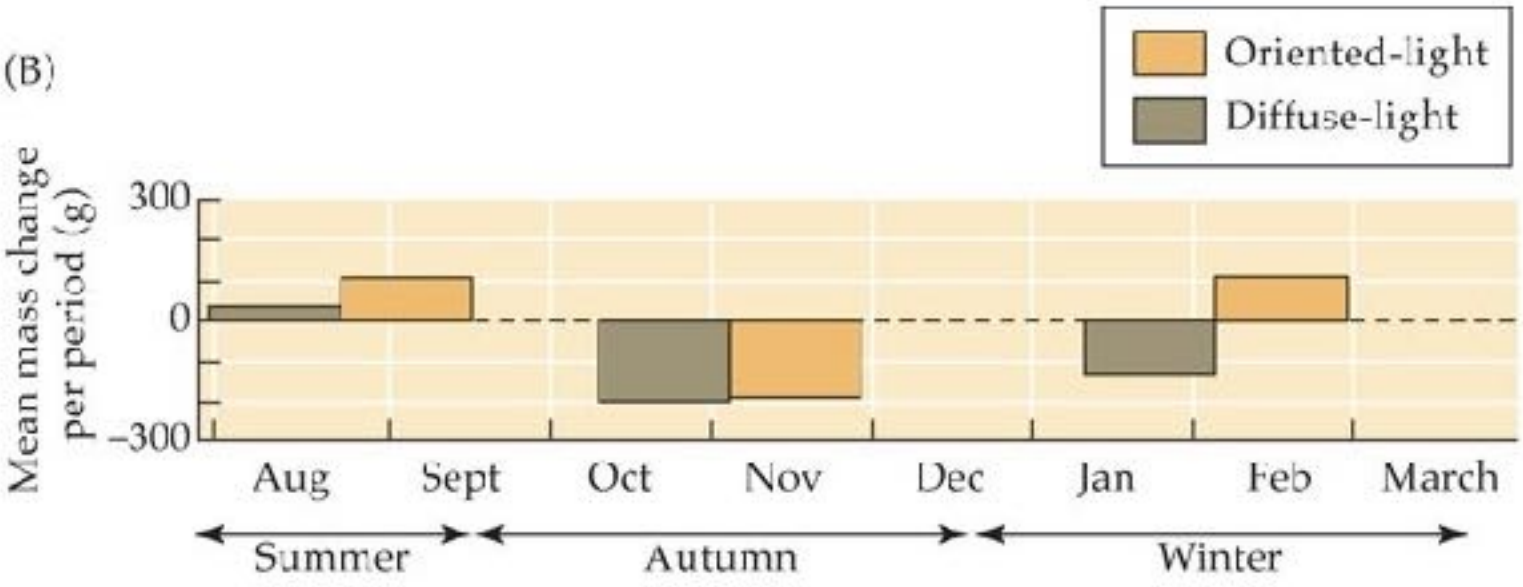
- Karl von Frisch
  - Expt. A = “Fan experiment” to test for directionality
  - Expt. B = “Step experiment” to test for distance





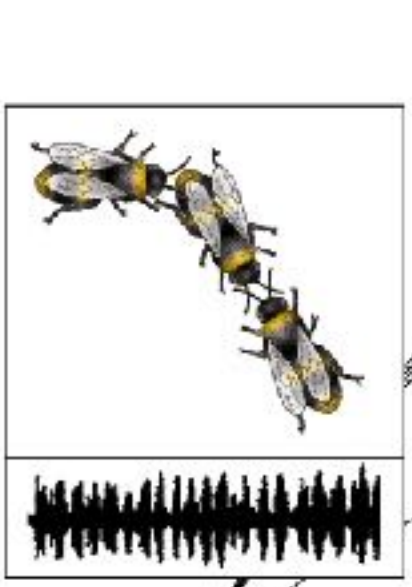
Value of dancing

- Bees generally use gravity as a directional reference, but will use experimental directional light
  - On horizontally-laid hives (unnatural), if light is oriented, bees use it as reference

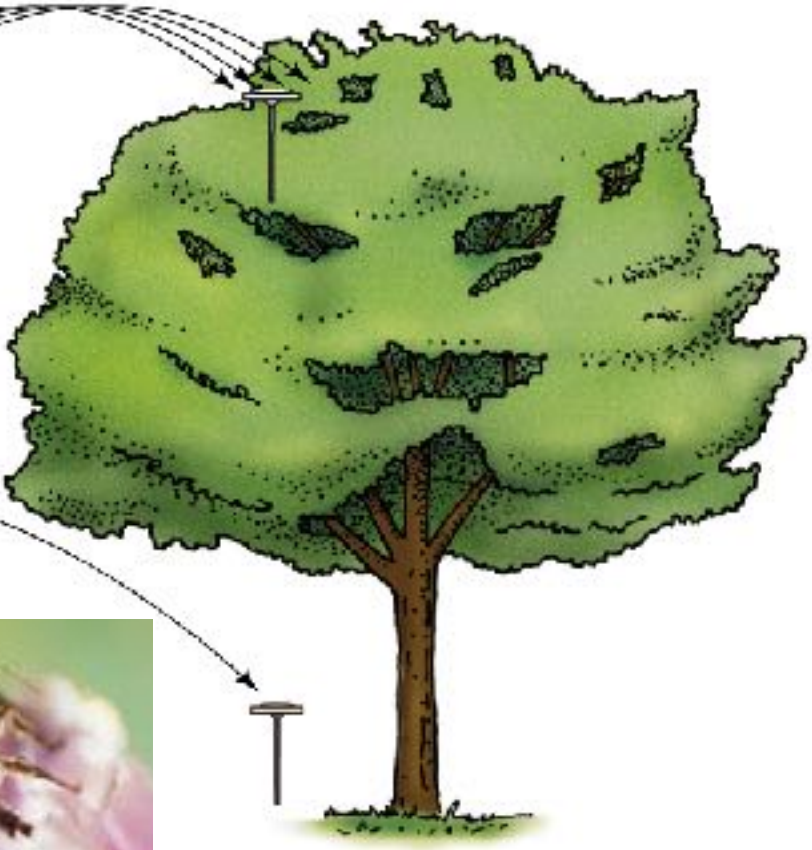


Some bees use sound, too

- Acoustic transfer of information about height
  - More recruits go to advertised site in canopy than at equally good site on ground



Nest



Stingless bee, Melipona