<u>It's more complicated than driving to the grocery store</u>

How do animals search for food? Why would different animals have different strategies for searching for food?

- Random: an animal simply walks around with no pattern and even after it finds food it continues in a random path
- Nonrandom: an animal searches areas it has found food in previously, follow scents or visual cues, or changes its pattern after it finds food (usually to search adjacent areas)

When you are trying to answer a scientific question, you have a choice of either running an experiment or doing an observational study. In an observational study, the scientist observes the subject (in our case, flies) in its natural environment. In an experiment, the scientist puts the subject in a controlled environment (usually in a lab, but today in a classroom!) in order to see how it will react to specific situations.

When you are trying to learn something about an animal, what would be better about running an experiment? What would be better about doing an observational study?

- Experiment: able to control variables and alter the ones you choose
- Observational Study: this is the animal's natural habitat, its behavior is truly unaltered

When animals search for food, they can search randomly. What do we mean by random?

- Random: each possible outcome has an equal probability of occurring at any given point (note: this does not necessarily mean that each possible outcome will happen exactly the same number of times)

Coin-toss experiment: If you toss a fair coin a number of times, 50% (½ or half) of the time you are going to get a Head and the other 50% of time you are going to get a Tail. This means you cannot predict very well what a certain toss is going to produce. This is random. However, if it is not a fair coin you can get either too many Heads or too many Tails (say 75% or more) and it is not a random outcome.

When an animal is (or you are) searching, it can make one of 2 possible choices at every step, 1) Turn Right, or 2) Turn Left. If the search is random, then you should see a similar number of these choices occurring.

If you roll a 6-sided die a dozen times, how many times would you expect to roll each number?

- Twice (12 x 1/6 = 2)

How would you search for Easter eggs? Is it smart to start searching randomly at first? Why?

- This is largely the student's opinion, but in discussion it might be useful to mention that a random search is helpful initially because the eggs could be hidden anywhere (equal possibility of them being hidden in any location in the house/yard = random)

Is it smart to change your strategy after you find the first egg? If so, how would you change your strategy?

- Once an egg has been found, information has been gathered about possible locations of other eggs, which means it is no longer random.

Materials:

- Houseflies
- Sugar water
- Square Petri dishes with fitted grids
- Timer or stopwatch
- Ruler

Pencil and paper

Exercise 1: Student Search

Instructions:

Before you perform this experiment with a fly, you will test two different search strategies in two different kinds of food patches. You will be given two grids that represent food patches but you do not know the location of the food items. You will take 24 steps on the grid, moving one square at a time, using a random and a non-random search. There are two possible moves on each step. 1) Turn Right 2) Turn Left

The group leader (the group's instructor or a student) will flip a coin 24 times and each student will write down the sequence of l's and r's that result.

In this part of the experiment, it may be necessary for an instructor to make sure that the number of heads and tails (left and right turns) stays as close to equal as possible since this is not a large enough number of flips to ensure that randomness is apparent to the students.

Random search strategy (By tossing a coin): Example:

R L R R L R L L L R R L R L L R R R L R L R L R

The group will decide whether they want to make more left turns or more right turns. Then each student will dictate a segment of the "turn sequence" (in groups of four each student would choose a sequence of 6 turns). A ratio close to 18:6 is sufficient to demonstrate to students the difference between a random and nonrandom search.

Non-Random search strategy: Example: (more right turns)

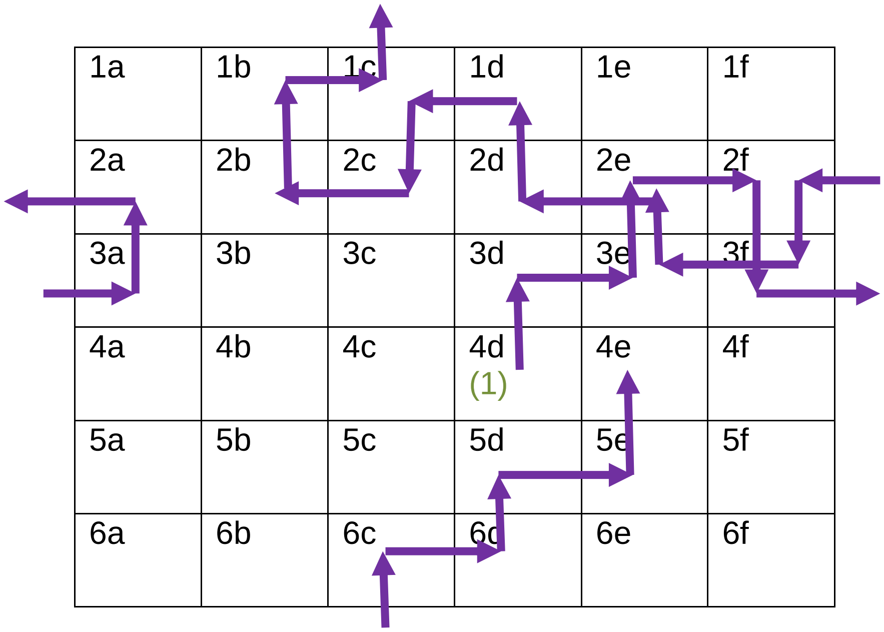
R R R L R L   L R R R L R   R R R L R R   L R R R R R

Map your two search patterns on the two grids below

To map the search strategies, students should start in one of the four center squares facing up (1) each turn should be diagrammed with an arrow that moves into the appropriate adjacent square.

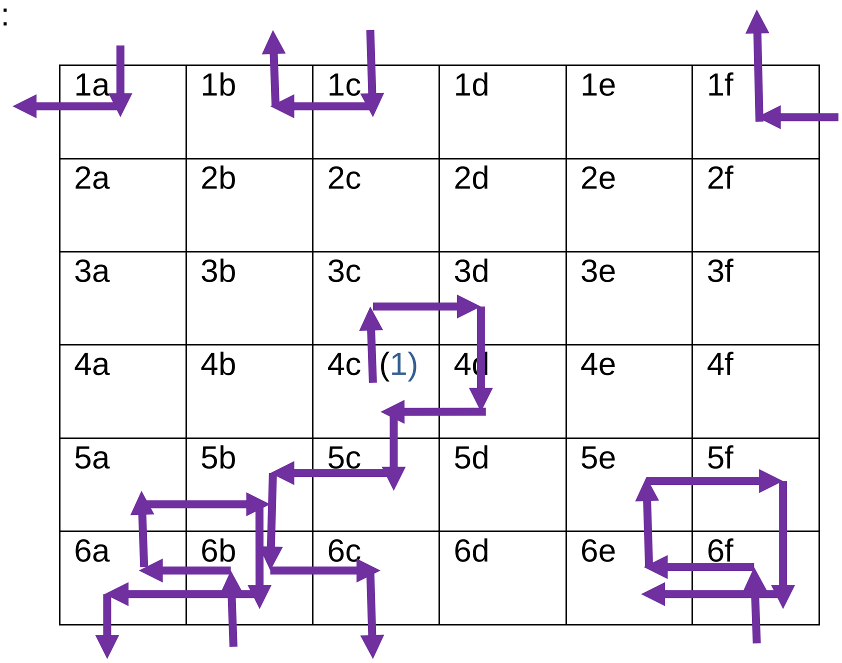
Note: it is often *very* helpful to students to turn the packet at each step so that the most recent arrow is pointed away from them. This helps them determine which direction is "left" and which is "right" from the perspective of standing on the page.

Random:



Note: if an arrow would take the path off the grid, simply connect it to the same row/column at the opposite side of the grid as if it was a circle, as in 3f to 3a, 2a to 2f, and 1c to 6c in the grid above.

Non-Random:



Now put the answer key that shows the distribution of food in the two patches (marked with X) on your search patterns. How many food items did the two strategies discover?

To determine how many food items each group found, simply lay the theoretical food patches on top of the students' mapped searches and see if they entered the squares that contained food items. Each food item can only be counted once. *It is important that the theoretical food patches be printed on overhead sheets so that the students can see their mapped searches through the patch.

Patch A: Random Strategy__________Non-Random Strategy______________

Patch B: Random Strategy__________Non-Random Strategy______________

How would you describe the two food patches? Did a certain search strategy work better for each patch? Why might this be?

Patch A represents a random food distribution and Patch B represents a clumped food distribution. Usually the random search is more effective for the random food distribution because it covers more "ground". A nonrandom search is often more effective for the clumped food distribution because it covers a smaller area more thoroughly. This may not be evident in every group's search, so it is useful to have a small discussion at this junction to help the students understand the relationship between the food distribution and the relative effectiveness of each search strategy.

Exercise 2:

Now we will run the experiment with the fly. The arena represents a patch where we place a drop of sugar water as food. Two group members will record all the turns the fly makes, and two will record the square the fly is in at each 10-second interval.

If each group has an instructor and a stopwatch, then groups may proceed to this segment as they finish the previous, but if students do not have instructors, it is highly recommended that the entire class start this portion simultaneously. This will make sure that the students understand *all* the instructions and it will allow one individual to call out the time intervals for the entire class.

Here you will write down every time the fly turns Right (R) or Left (L). Be sure that you write down the directions according to the *fly's perspective.* (If you are having trouble with this, just imagine yourself as the fly). Make sure you note when the fly finds the food, so that you can count the number of left and right turns before the fly finds the food and after.

In this segment, there are four student tasks:

Observers:

1) One student will observe the number of turns the fly makes. All they do is watch the fly and call out left or right when the fly deviates from a straight line.

2) Another student will watch the fly's spatial position. They should note the starting position of the fly as it is placed in the arena. Every ten seconds (when the stopwatch beeps or the time keeper calls out) they will simply call out the square that the fly is in.

Recorders:

1) One student will record the fly's turns as the observer calls them out. It is important that this recorder make some mark at the point where the fly finds the food. (a big dark dash in the sequence of L's and R's is simple and effective)

2) The other recorder will write down the coordinates that the second observer calls out at each 10 second interval.

Number of Right Turns (before finding food):_______________ Fraction:

Number of Left Turns (before finding food): ________________ Fraction:

Number of Right Turns (after finding food):________________ Fraction:

Number of Left Turns (after finding food):__________________ Fraction:

*It is advisable for an instructor to check the student's math in this section before the entire group plots the data.

On this grid note the position of the fly at each recording time, starting from 1 and continuing up to 24.

Now the students will map the fly's search similarly to how they mapped the theoretical search. An easy way is to write the interval number in the square the fly was in at that interval.

When the students measure the distance between the different interval positions, they should measure from the **center** of the first square to the **center** of the next interval's square to keep it consistent.

When recording the distances, #1 is the distance between start and interval one, #2 is the distance between interval 1 and interval 2 and so on.

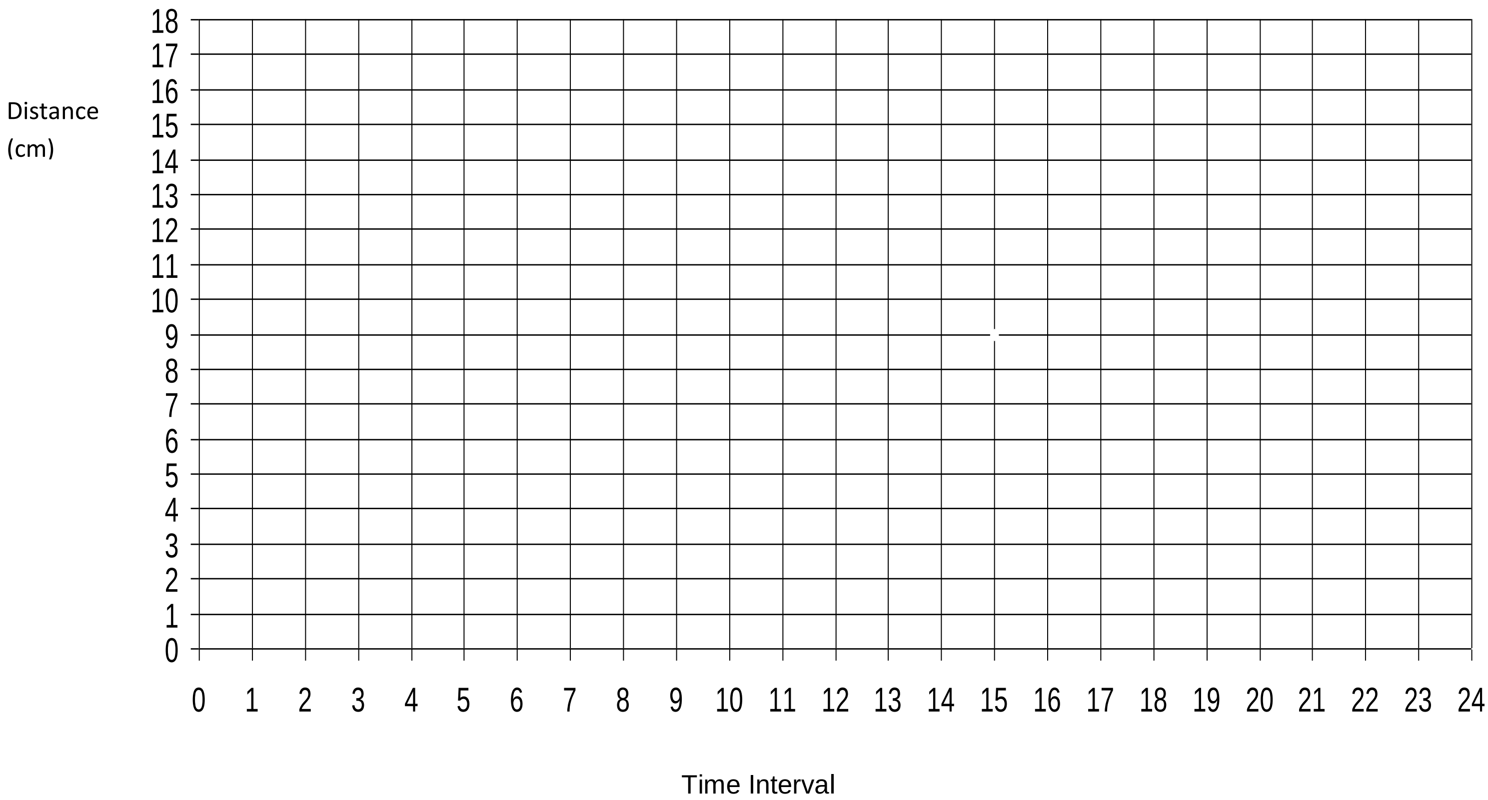
1a	1b	1c	1d	1e	1f
2a	2b	2c	2d	2e	2f
3a	3b	3c	3d	3e	3f
4a	4b	4c	4d	4e	4f
5a	5b	5c	5d	5e	5f
6a	6b	6c	6d	6e	6f

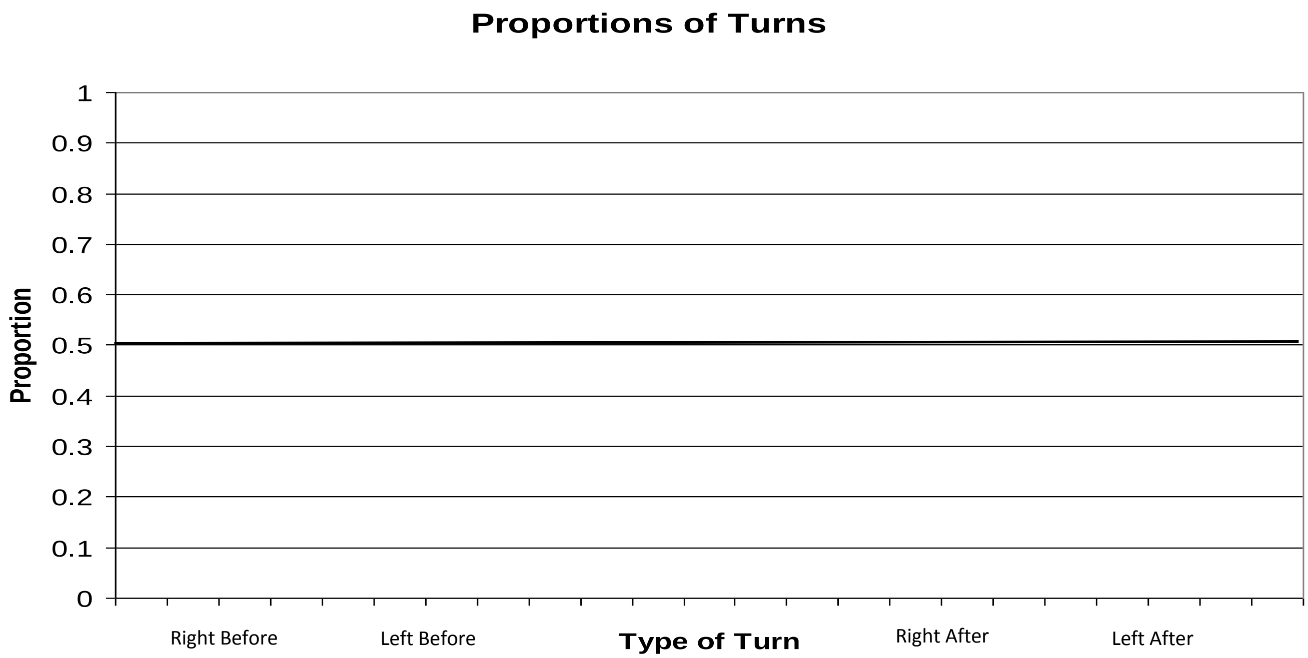
Now you can measure how far the fly walked between each time interval:

1)	2)	3)	4)	5)	6)	7)
8)	9)	10)	11)	12)	13)	14)
15)	16)	17)	18)	19)	20)	21)
22)	23)	24)	25)	26)	27)	28)
29)	30)					

Depending on the age of the students, the graphing component may be challenging. If students have learned how to draw a best-fit line then it should be drawn on the first graph.

Plot the distance the fly traveled in each time interval. Draw a line on the time point when the fly found the food, then plot the points of all the distances you recorded on the previous page.





Did the distance the fly traveled in each time interval change after it found the food? If so, why do you think this happened?

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Did the fly change the way it turned after it found the food? If so, why do you think this happened?

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Both of these questions depend on the group's data, but in the concluding discussion it may help to point out that if a fly turns mostly in one direction, it tends to stay in a smaller area, which would keep them closer to food they already found, indicating that they have chosen to search for food in a location that is known to contain food. On the other hand, if a fly turns each direction equally, they will likely cover a larger area.

In the concluding discussion, topics similar to these will help the students relate the things they learned in this experiment to other natural situations:

- Animals have different types of transportation (flying, swimming, running) which may affect the types of terrain and the amount of terrain they cover.
- Animals eat different types of food. If they have an idea of where that food is, they may search nonrandomly, but if their food source is randomly distributed, they may use a random search strategy.
- Animals may search by different mechanisms (sight, smell, cooperation within groups)
- Some animals are searching for stationary food (herbivores) and others are searching for mobile food (carnivores), so different search strategies would be necessary