Unit 3: Population Ecology

Ecology is the

- Study of interactions between organisms and their environment
- Includes both **abiotic** and **biotic** factors

Peurto Vallarta, 2009

Biotic and Abiotic

Biotic factors: **<u>living</u> components**

Ex. Plants, animals, fungus, bacteria,

Abiotic factors: **<u>non-living</u>** components

Ex. Temperature, soil pH, light, water, carbon dioxide

Populations vs. Communities

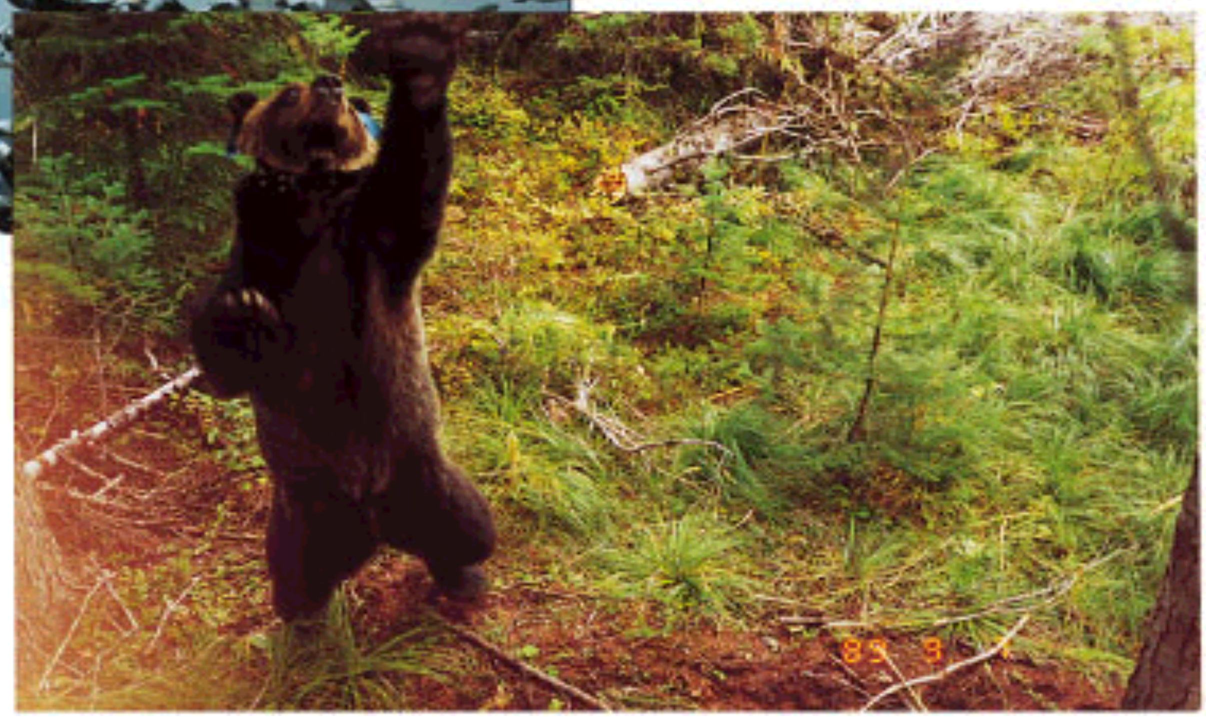
- **Population:**
  - **Any group of individuals of the same species living in the same place at the same time**

Ex. Clown fish

- **Community**
  - **2 or more populations**

Ex. Clown fish, sea horse….

Same species: Same place: Same time!



Animal populations

Ecosystems: Community or Population?

A fallen tree holds a thriving **community** of organisms

Why is the picture an example of *a community* and not an example of a population?

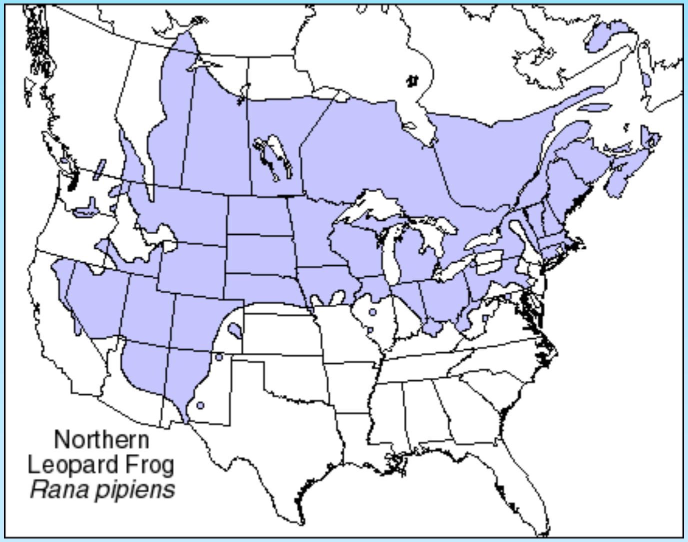
There are many populations living there.

Populations

- Variables we will consider:
  1. Geographic Range
  2. Habitat
  3. Ecological Niche
  4. Population Distribution
  5. Population Size
  6. Population Density
  7. Population Growth Rate and Patterns

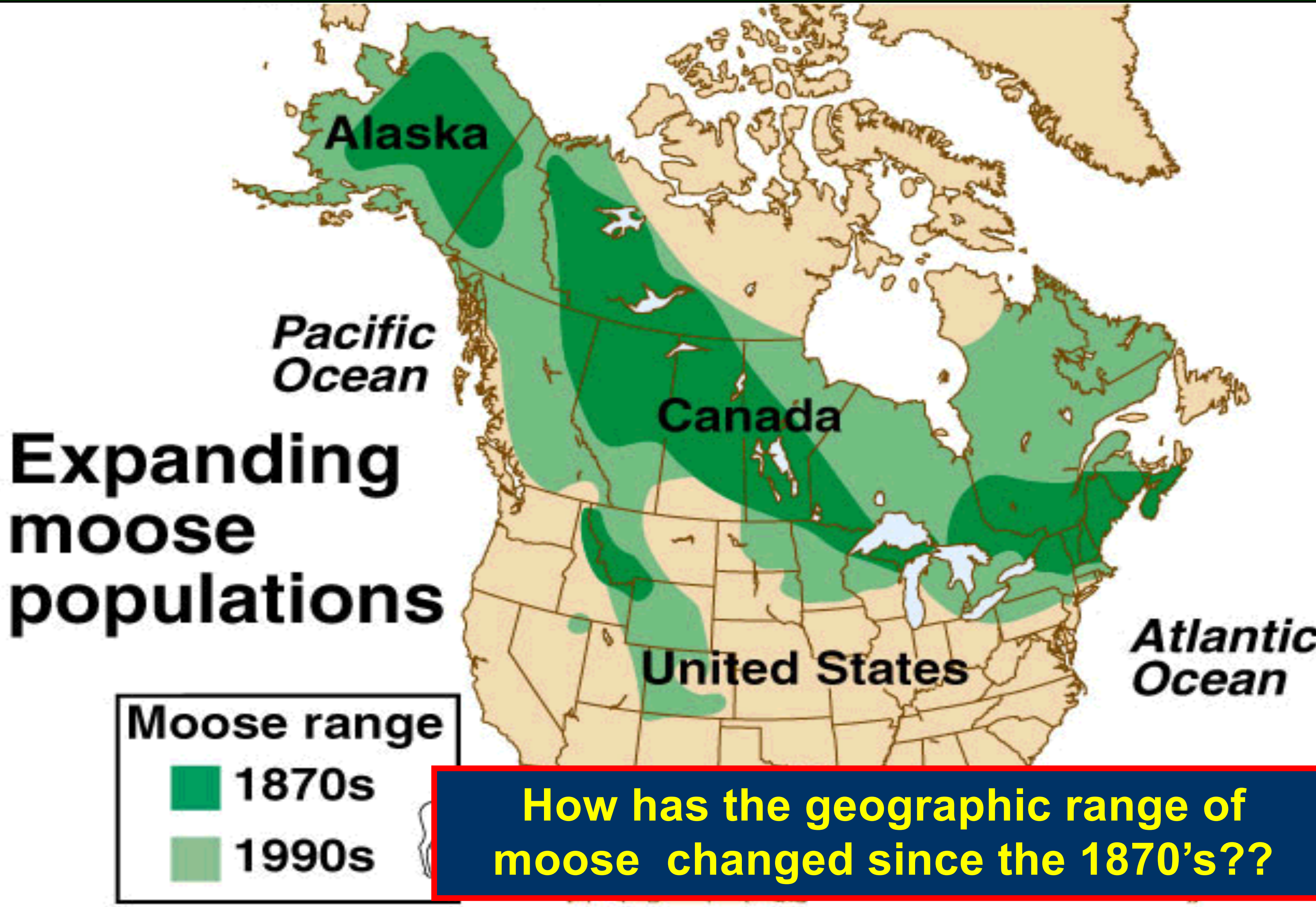
1. Geographical Range

- Where the animal has been seen
- Usually outlined on a **map**
- Can change over time due to biotic and abiotic factors



For example: The Northern Leopard Frog has been seen in the Northern United States, mostly on the Eastern and Central areas of the country

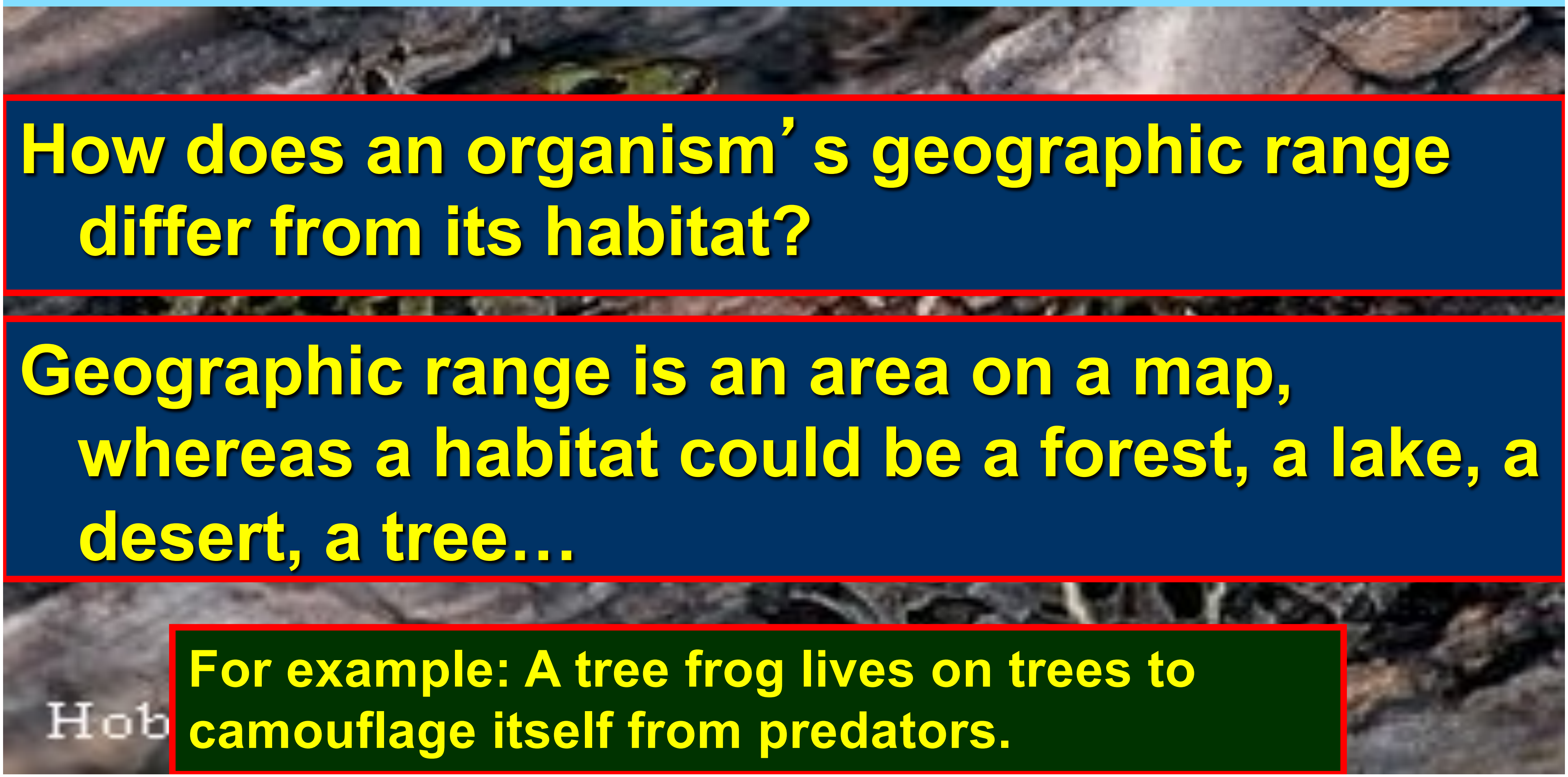
Range Changes in Moose Populations



How has the geographic range of moose changed since the 1870's??

2. Habitat

- area where the population lives
- where environmental conditions are best for survival



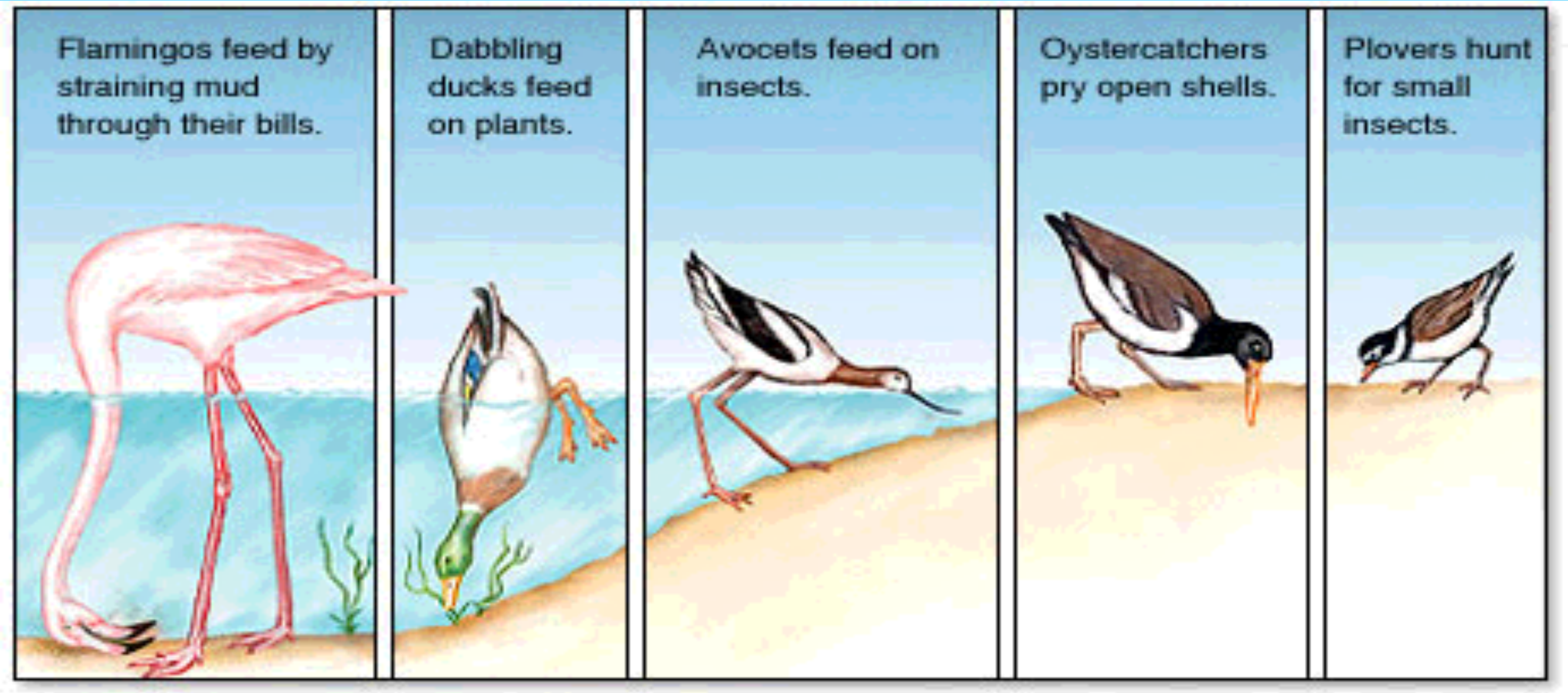
How does an organism's geographic range differ from its habitat?

Geographic range is an area on a map, whereas a habitat could be a forest, a lake, a desert, a tree…

For example: A tree frog lives on trees to camouflage itself from predators.

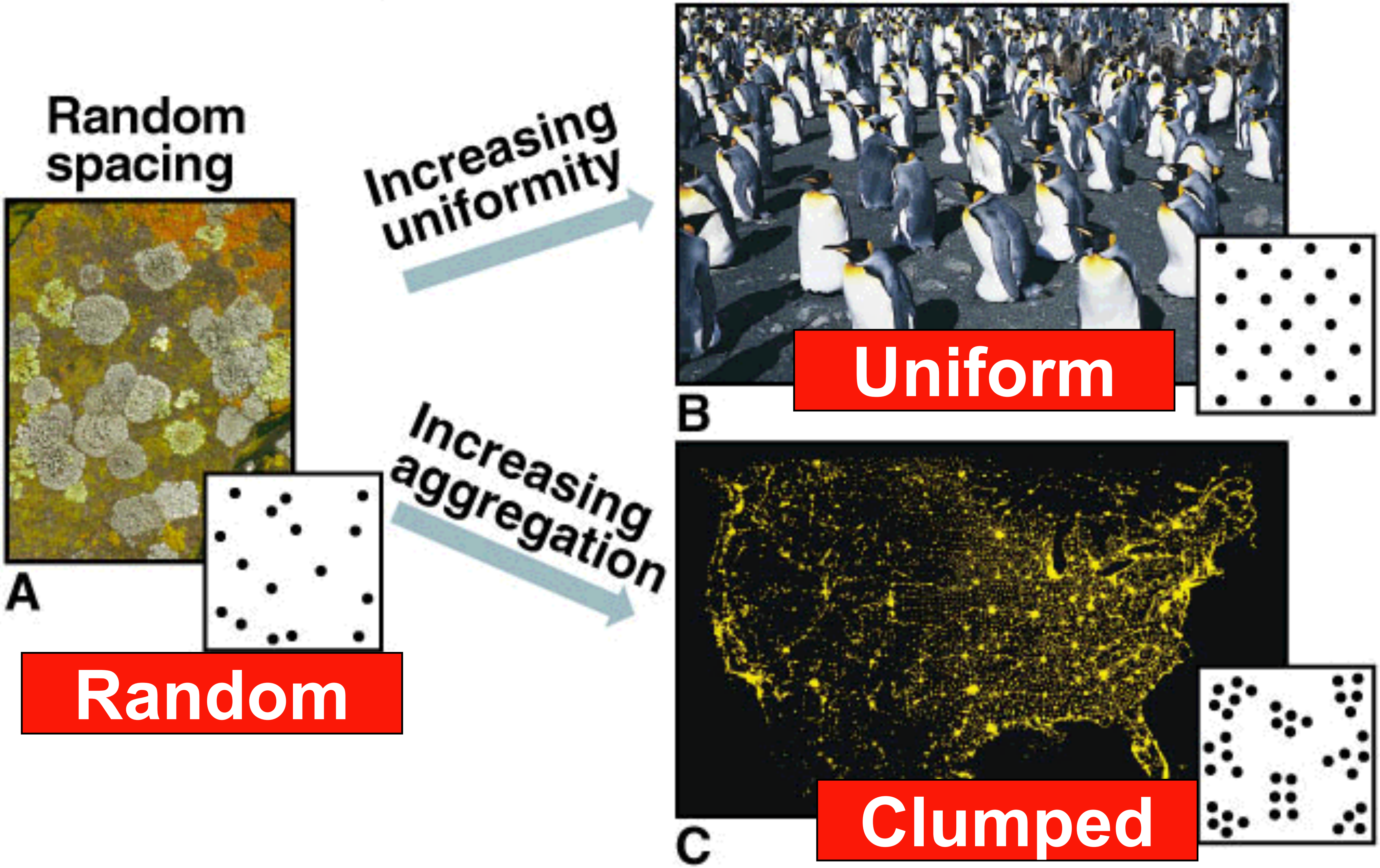
3. Ecological Niche

- **Role** of the species in the community (an organism can have more than one role) **your niche is student, mine is teacher**
- Includes ALL *biotic and abiotic* factors a species needs to survive



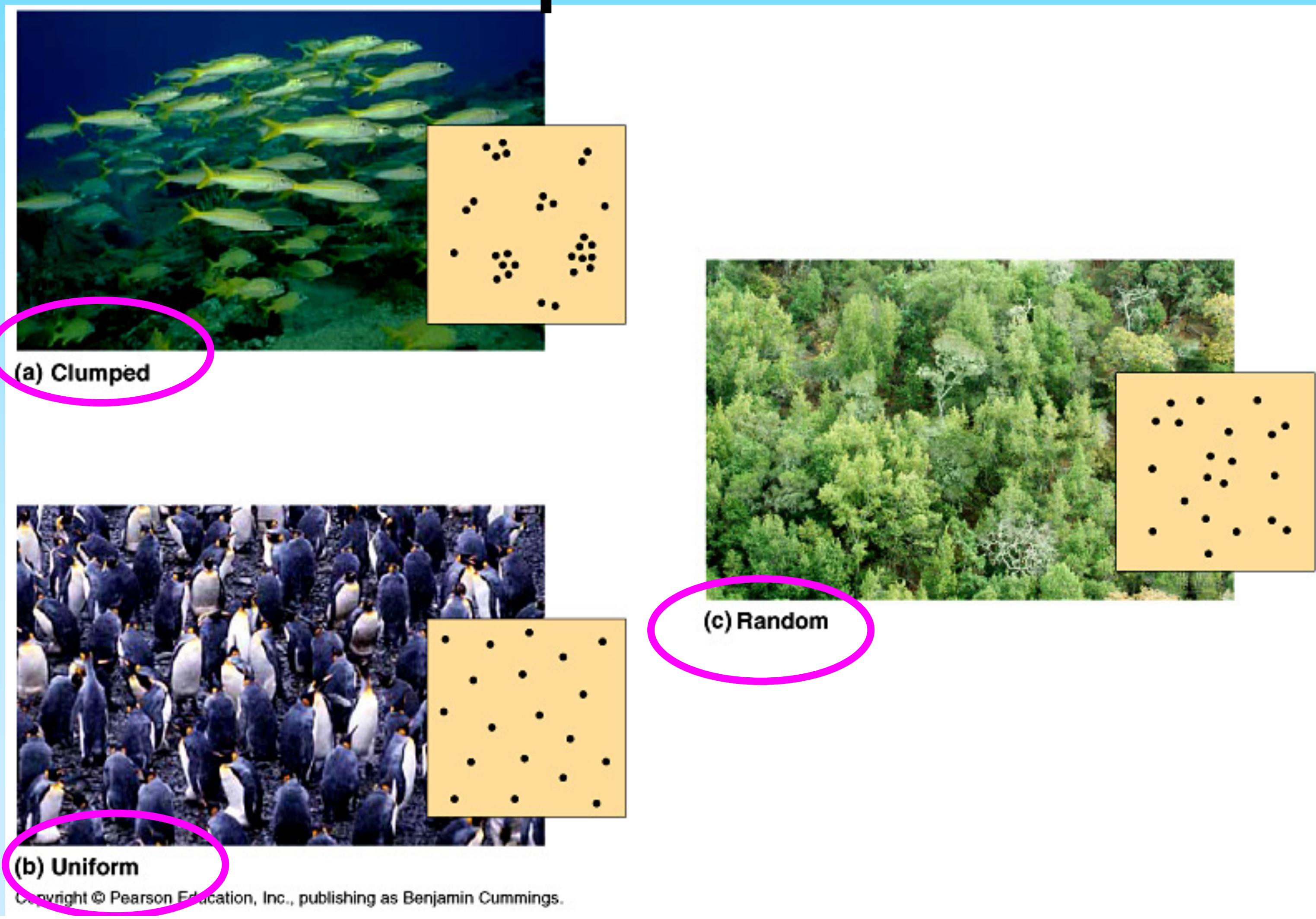
Each group has a different role to minimize competition

4. Population Distributions



4. Population Distributions

- Determined largely by **habitat preference**
- Divided into three patterns:

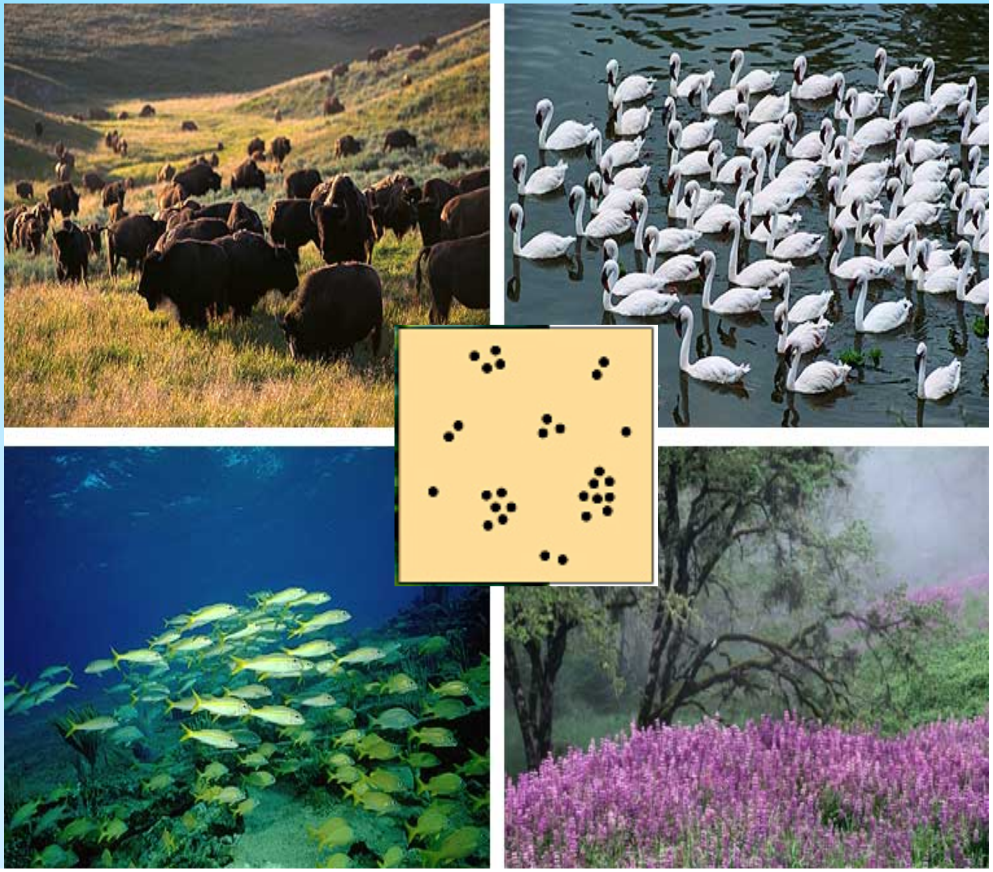


4. Population Distributions

Clumped

- **Most common**
- **Individuals are clustered in patches…like herds**
- **Result of environmental factors and social behaviors**

Ex. Buffalo, geese, fish, seagulls



Name that Clump!!!

Buffalo

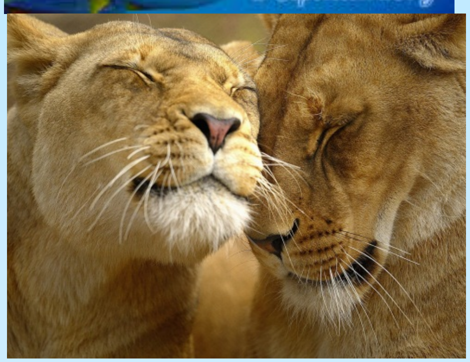
Herd

Geese

Gaggle

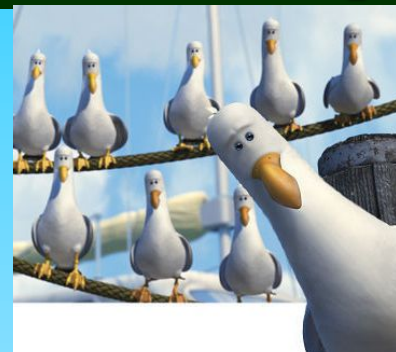
Fish

School



Lions

Pride



Seagulls

Flock

Whale

Pod

Wolf

Pack

Jellyfish

Smack

Name that Clump!!!

Clams

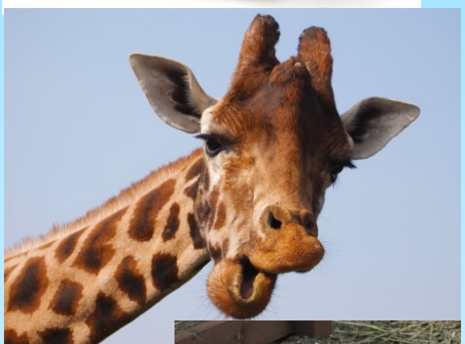
Bed

Crows

Murder

Beaver

Colony



Giraffe

Tower

Hen

Brood

4. Population Distributions

Random

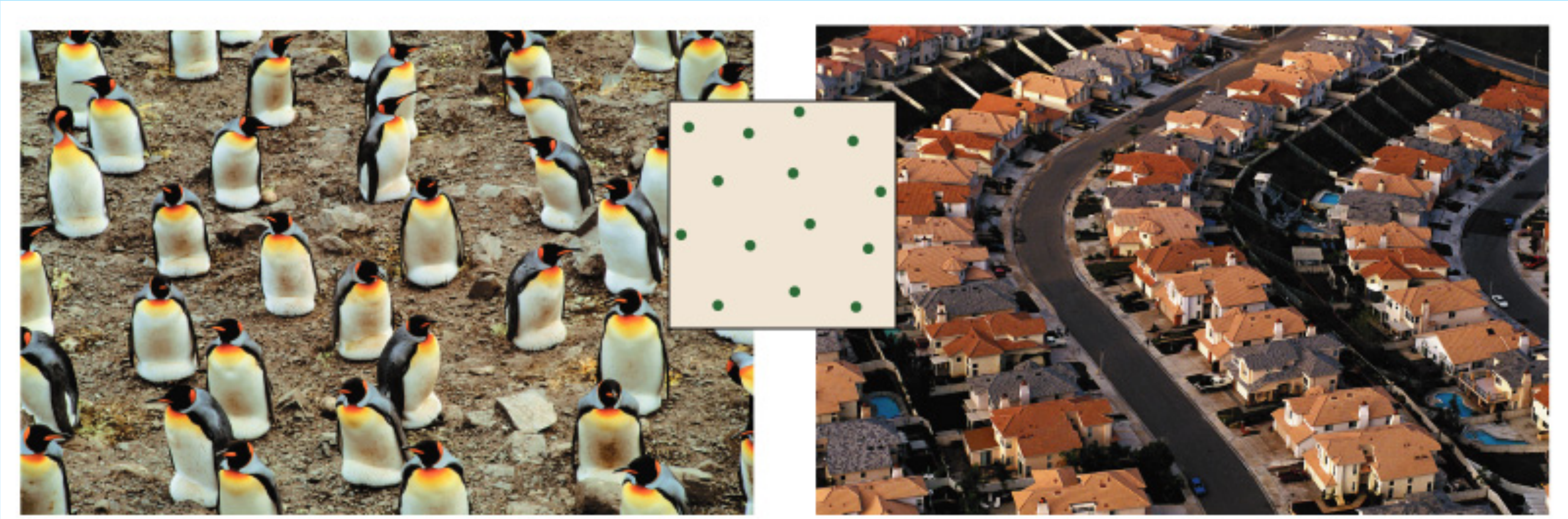
- Not very common
- No attraction nor repulsion among members
- Biotic and abiotic factors have little effect on random distribution
- Abundant resources available

  ex. Plants

4. Population Distributions

Uniform

- Occurs when there is **competition** among individuals (nutrients, light, space)
- Common in **territorial**



5. Population Size

- Organisms of **same type** in same **place,** at same **time**
- There are **490 students** at SAB during the **2018/2019** school year.
- Can be determined by exact count or estimation!!

6. Population Density

Describes number of organisms in a defined area

- Ex. Number of penguins/km^2

- **Density (D) calculated by dividing total number (N) by amount of area (A) or volume (V) occupied by the population**

Density → $D_p = \frac{N}{A}$ ← Total # of individuals (N); Area (A), $A = l \times w$

or

$D_p = \frac{N}{V}$ ← Volume (V), $V = l \times w \times h$

Population Density con’t

Formula Manipulation

This formula calculates for density…

-we can also manipulate it to calculate for “N” and/or “A”

$$D_p = \frac{N}{A}$$

TO FIND ”N”

$$N = A \times D$$

TO FIND ”A”

$$A = N / D$$

6. REMEMBER - Pop. Density

When using $D_p = \frac{N}{A}$ remember what the formula is doing for us.

Its figuring out how many individuals there are

<u>per 1 unit of the area.</u>

Eg. - There could be 14 people in this classroom of 300ft^2 …..which I suppose 14 / 300ft^2 is a sort of density

HOWEVER its hard to compare this density with other classroom populations like 18 / 350ft^2 and 12 / 250 ft^2. Which is <u>most dense</u>?…its too close to call…

By using the formula we can compare populations accurately:

14/300 = .047student/ft^2 **18/350 = .051 student/ft^2** **12/250 = .048student/ft^2**

Density Example 1

There are 80000 snow geese in a 50 hectare area in 1995.

$$D_p = \frac{N}{A}$$

$$D_p = \frac{N}{A} = \frac{80000}{50} = 1600 \text{ geese/ha}$$

What if we wanted to know how many in 50 hectares?

1600 X 50 = 80,000

Density Example 2

If 200 lemmings are living in a 25 hectare (ha) area of tundra, what is the population density of this area?

$$D_p = \frac{N}{A}$$

$$D_p = \frac{200}{25}$$

D_p = 8 lemmings/ha

A myth, invented by Disney, showed hundreds of Lemmings committing mass suicide in the 1950's.

Based on this myth, the term "lemming" is often used in slang to denote those who mindlessly follow the crowd, even if destruction is the result!!

OVERPROTECTIVE LEMMING PARENTS


LEMMING
TOUR LINE


off the mark
by Mark Parisi
www.offthemark.com
YES, SCOTT...IF ALL YOUR FRIENDS JUMP OFF A CLIFF, THEN YOU SHOULD, TOO...
offthemark.com
PARENTING FOR LEMMINGS

Density Problem Example 3

Calculate the population density of shrews per m^2, if an average of 7.8 shrews are found in an area 14 m by 20 m.

Example 3 - Answer

$$D_p = \frac{N}{A}$$

$$D_p = \frac{7.8 \text{ shrews}}{14 \times 20} = \frac{7.8}{280} = 0.03 \text{ shrews/m}^2$$

Example 4 - volume

- If 200.0 ml of pond water contained 52 mosquito larvae, then the density would be:
- Dp = N/A = 52 M.L / 200.0 ml <u>= 0.26 M.L / ml</u>
- This info could be used to estimate the size of a population of mosquito larvae in a given area

WORKBOOK page 6(right side),7 (left side)

Population Growth

Determined by four factors:

1. **Natality (birth)**
2. **Mortality (death)**
3. **Immigration (in)**
4. **Emigration (exit)**

SO…

the amount a population **changes in size** (+ or -) can be shown as the following…

$$\triangle N = (\text{natality} + \text{immigration}) - (\text{mortality} + \text{emigration})$$

(change in population number)

Population Growth

(change in population number)

$\triangle N$ = (natality + immigration) – (mortality + emigration)

And / OR

$\triangle N$ = (most recent pop.) – (initial population)

1980 the population was 9000
1998 the population is 7500

So… N = 7500 – 9000
N = -1500

Population Growth

While calculating the change in a population is of great value, scientists are often more interested in the:

GROWTH RATE (gr)

HOW **FAST** A POPULATION IS CHANGING

$$gr = \frac{\Delta N}{\Delta T}$$

Population Growth Rate and Patterns

- The growth rate is the rate of change over time

Growth rate

$$gr = \frac{\Delta N}{\Delta T}$$

Change in pop. size
(most recent data first)

Change in time
(most recent date first)

Rate of growth
(how fast a change is occuring)

***Note: answer is either + or -**

Growth Rate: Example 1

In 1993, the mouse population in my backyard was 50 mice. After three years, various control measures had been in place, and the population dropped to 10 mice. Calculate the growth rate.

IMPORTANT!!!
(most recent data first)

$$gr = \frac{\Delta N}{\Delta t} = \frac{10 - 50}{3} = \frac{-40}{3}$$

$$= -13.3 \text{ mice/year}$$

Growth Rate: Example 2

A collared pika population dropped from exactly 25 individuals in 1998 to 5 individuals in 2000. Calculate the growth rate of this population from 1998 to 2000.

$$g.r = \frac{\Delta N}{\Delta t}$$

IMPORTANT!!!
(most recent data first)

$$= \frac{5 - 25}{2000 - 1998} \qquad = \frac{-20}{2} \qquad = -10 \text{ pika / yr}$$

cgr : per Capita Growth Rate

$$cgr = \frac{\Delta N}{N}$$

Represents a change in population size relative to the initial size

In other words…

Per individual, what is the population change?

$$cgr = \frac{(\text{births} + \text{immigration}) - (\text{deaths} + \text{emigration})}{\text{initial \# of organisms}}$$

$$cgr = \frac{(b + i) - (d + e)}{N_i}$$

IMPORTANT!!

CGR can be expressed as a DECIMAL or a PERCENTAGE

(eg.) A CGR of 0.02 is multiplied by 100 to get 2%

What does CGR mean exactly?

Lets say the calculated CGR is .5 in a population.

This means that for every individual in the initial population, the population has grown .5 of an individual. So….. If the initial population is 10 individuals the population will have grown to 15 (.5 per each of the 10 initial individuals)

ANOTHER COMPARISON

A population of 2000 individuals that grows by 40 in one year has a CGR of 0.020 or 2%

(for each individual the population grew by 0.02 per individual)

COMPARED TOO…

A population of 200 individuals that grows by 40 in one year has a CGR of .2 or 20%

(for each individual the population grew by 2 per individual)

RESULT: we can easily see that although both populations grew by 40 members, the second population grew much more rapidly

CGR Example 1

Using this table, calculate CGR for Sandhill cranes:

Births	Immigration
40	0
Deaths	**Emigration**
55	0

Original Pop = 200

$$cgr = \frac{\Delta N}{N}$$

$$cgr = \frac{(b + i) - (d + e)}{N_i}$$

$$cgr = \frac{(40 + 0) - (55 + 0)}{200} = \frac{-15}{200} = \underline{-0.075}$$

CGR Example 2

- Puffins are small marine birds found off the coast of Atlantic Canada. Calculate the per capita growth rate of a puffin colony based on the following population in 1999.

Orig. pop. = 200 000
Natality = 15 000
Mortality = 10 000
Immigration = 175 000
Emigration = 160 000

$$cgr = \frac{\triangle N}{N}$$

$$cgr = \frac{(15\,000 + 175\,000) - (10\,000 + 160\,000)}{200\,000}$$

$$= \frac{190\,000 - 170\,000}{200\,000} = \frac{20\,000}{200\,000} = 0.1$$

CGR Calculation Example 3

Calculate the per capita growth rate of a mouse population if the original population size is 34 and over a period of a week, 5 die, 8 are born, 12 immigrate into and 7 emigrate out of the area.

$$\text{cgr} = \frac{\triangle N}{N}$$

$$\text{cgr} = \frac{(8 + 12) - (5 + 7)}{34} = \frac{20 - 12}{34} = \frac{8}{34} = 0.24$$

Growth Rate Example 4

Over 2 years, a population of 900 experienced 66 births and 14 deaths. Five individuals left the population and 13 individuals joined the population. Using this information, determine the <u>growth rate</u> as well as the <u>per capita growth rate</u>.

$$gr = \frac{\triangle N}{\triangle t}$$

$$gr = \frac{\triangle N = (b + I) - (d + e)}{\triangle t} = \frac{(66 + 13) - (14 + 5)}{2} = 30$$

= 30 individuals

NOTE – DATA IS OVER TWO YEARS so don't have to worry about adding two years of data

$$cgr = \frac{\triangle N}{N} = \frac{60}{900} = .067$$

= .067

1. A biologist studied the number of caribou in the area surrounding Jasper for a period of 20 years. The initial population was 46 caribou. She determined that the natality averaged 2 caribou per year, the mortality averaged 4 caribou per year, while the immigration was 2 caribou per year and the emigration was 3 caribou per year.

a) Calculate the growth rate of this population in the first year of the study.

b) Calculate the per capita growth rate (cgr) for this population of caribou during the entire study period. (remember: data is given per year but question is about 20 years so you have to ΔN for 20 years.

WORKBOOK page 6(right side),7 (left side)

Dynamic Equilibrium

- Present in mature ecosystems
- Characterized by long term balance
- Pops remain relatively stable over time
- Great biodiversity = stability
- Can be compared with homeostasis

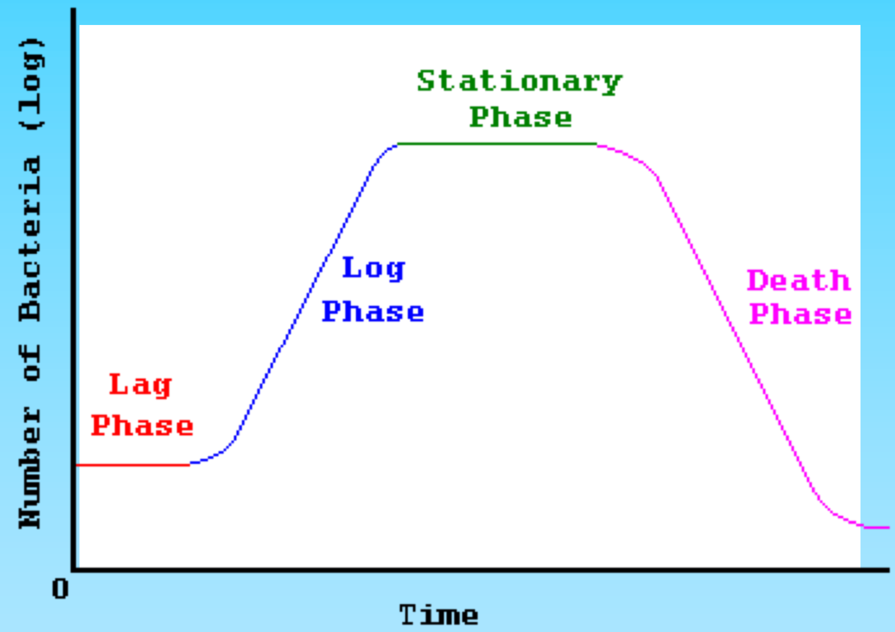


Two population types:

- Open populations:
  - immigration & emigration occurs
- Closed populations:
  - Density changes are result of natality and mortality only
  - No immigration or emigration
  - eg. Game preserves

Growth Curve

- Graph showing fluctuations in a population over time. These changes can be examined and then analyzed.
- X axis = time (independent or manipulated variable)
- Y axis = density or # of organisms (dependent or responding variable)



Population Growth Patterns

Two Types of Graphs/Curves to know:

1. Exponential Population Growth: J-Curve

- This model predicts **unlimited population increase under ideal conditions** (usually a closed pop.) of unlimited resources and then a sharp decline in the population

2. Logistic Growth: S-Curve

More representative of population in nature

- This model incorporates the effects of **resource limitation and crowding** on the population growth rate

Population Growth Patterns

1. **Exponential Population Growth: J-Curve**

There four phases in this type of growth pattern:

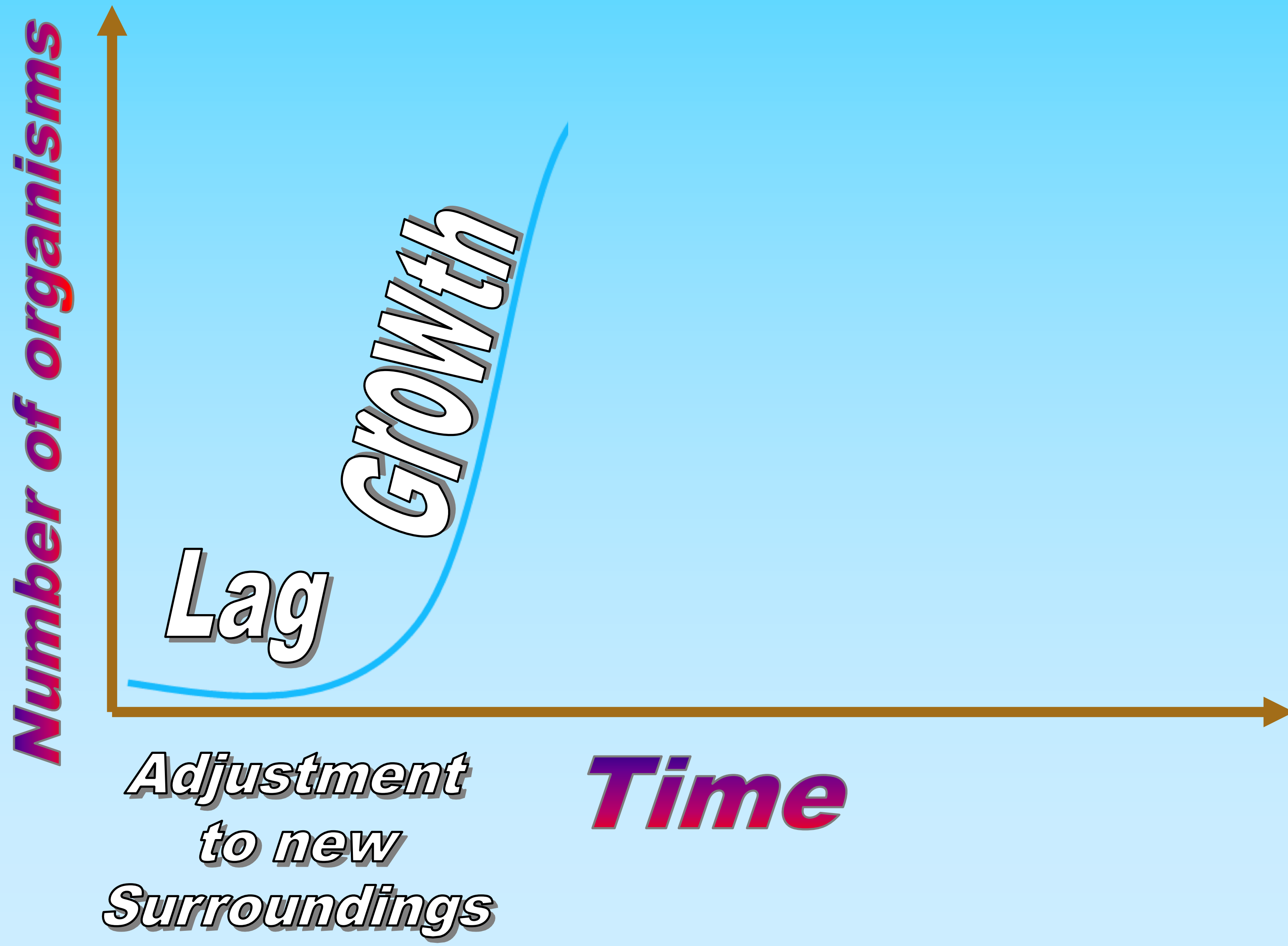
1. Lag phase
2. Growth phase
3. Stationary phase
4. Death phase ("crash")

- Examples of organisms that exhibit exponential growth include bacteria, yeast, some insects

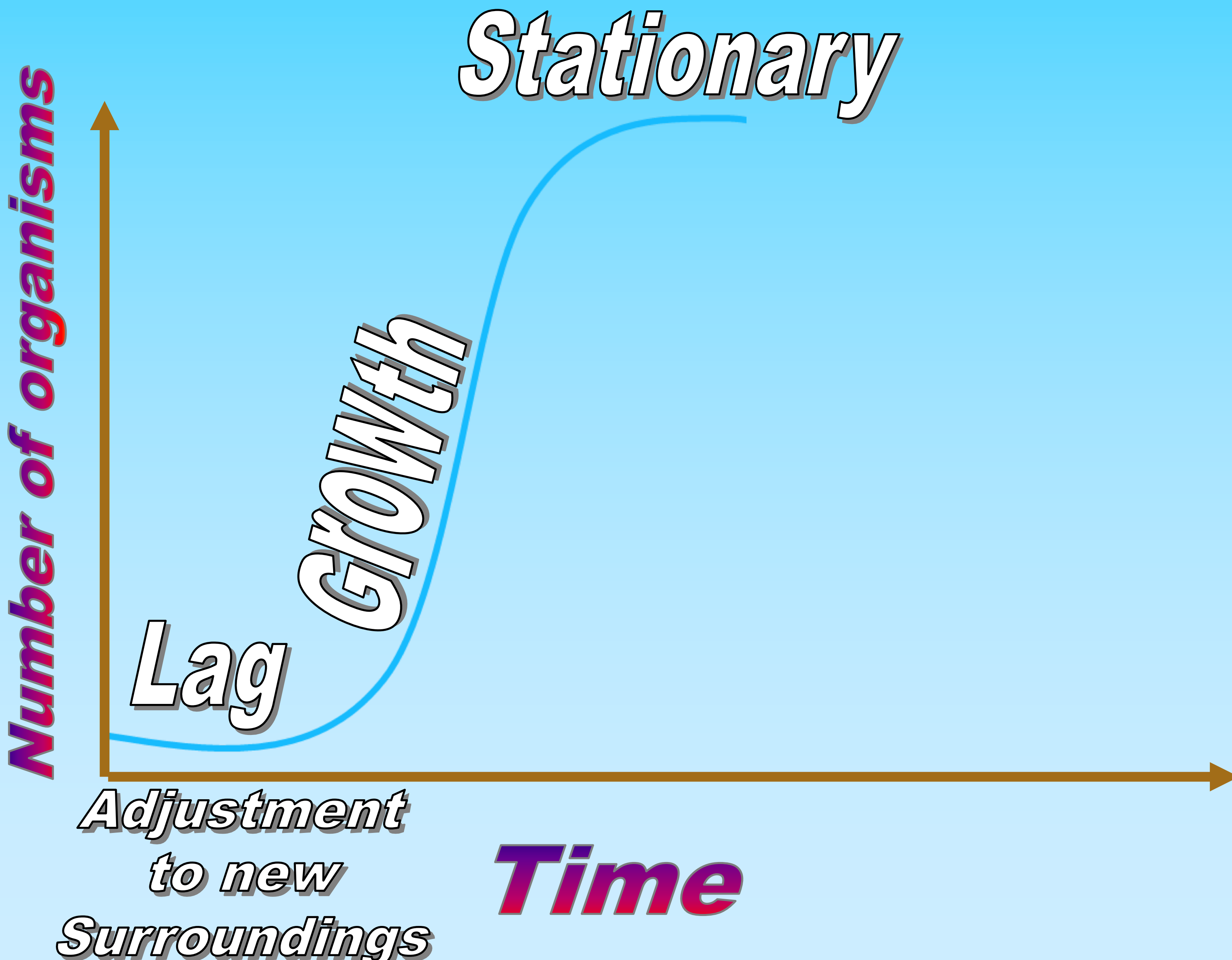
J-Curve


Number of organisms
Lag
Adjustment
to new
Surroundings
Time

J-Curve

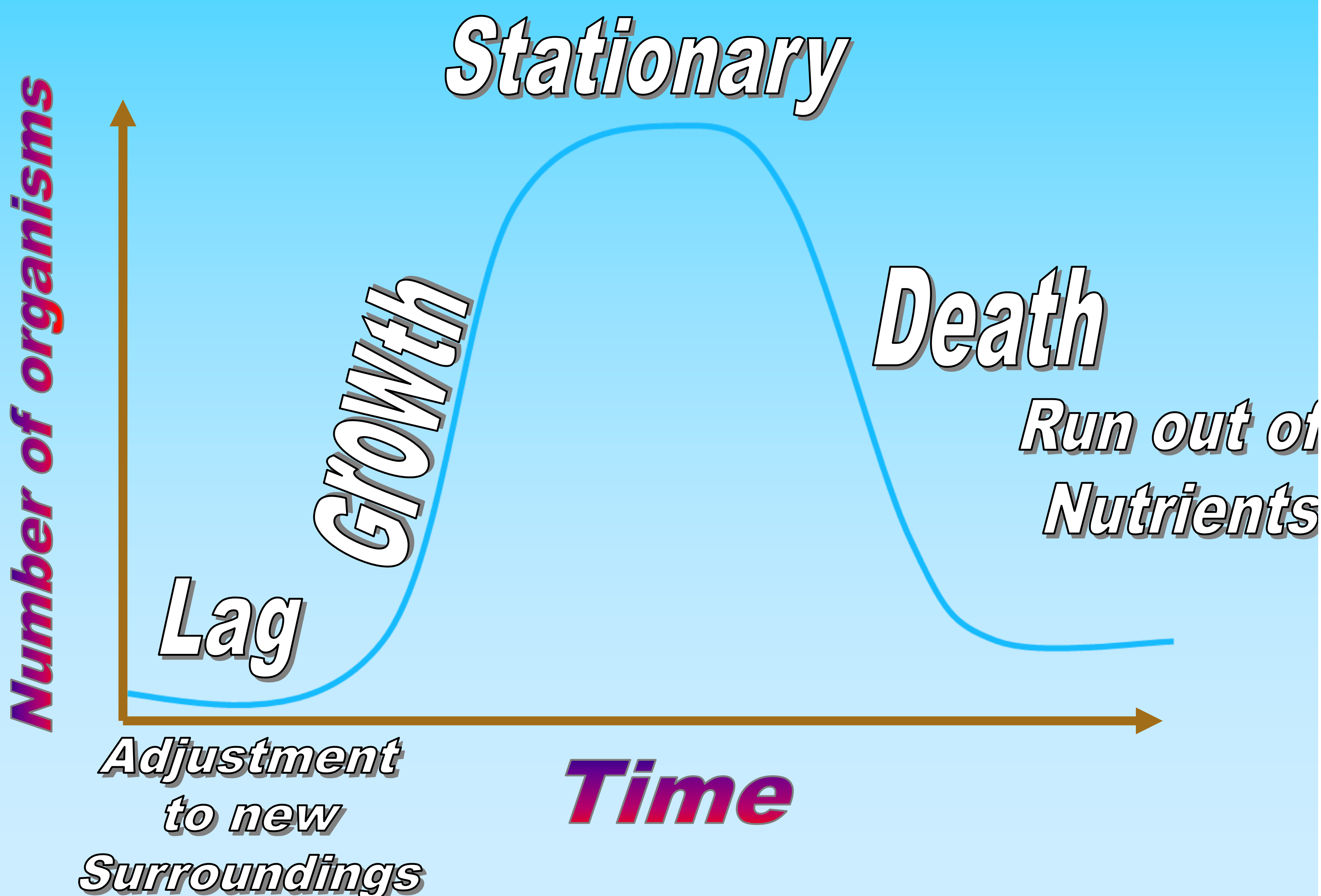

Number of organisms
Growth
Lag
Adjustment to new Surroundings
Time

J-Curve

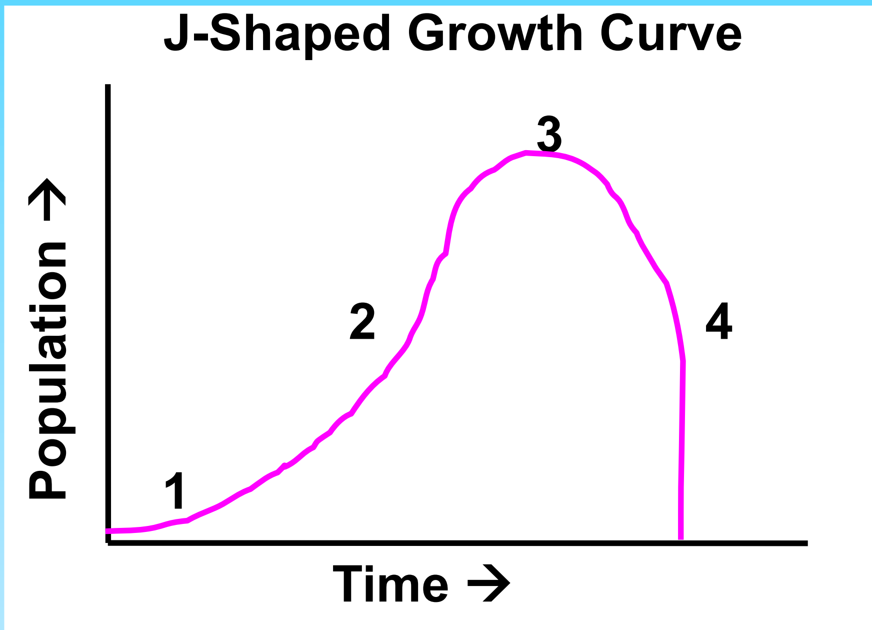


Stationary
Growth
Lag
Number of organisms
Adjustment to new Surroundings
Time

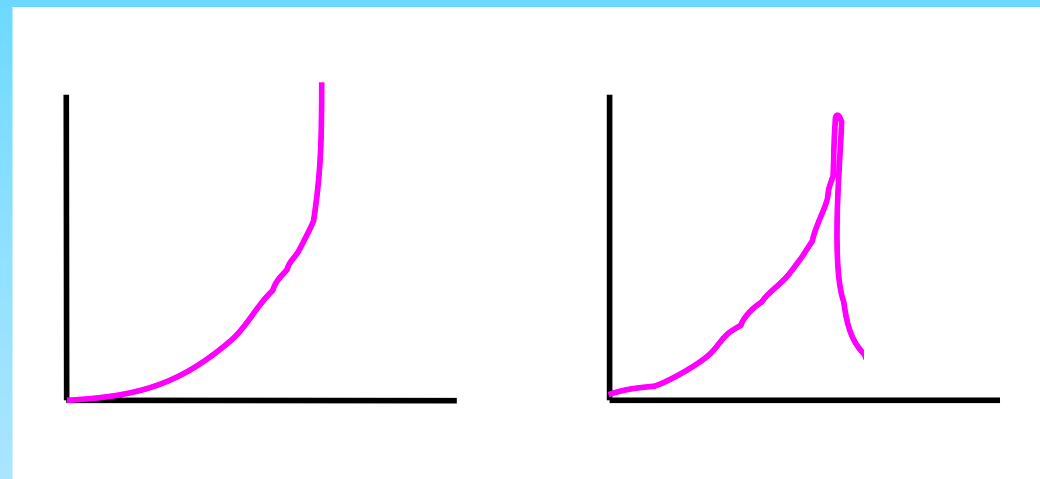
J-Curve


Stationary
Growth
Lag
Death
Run out of
Nutrients
Number of organisms
Adjustment
to new
Surroundings
Time

CLOSED population growth curve, Exponential Growth Curve, or J-Shaped Growth Curve



Could also look like these:

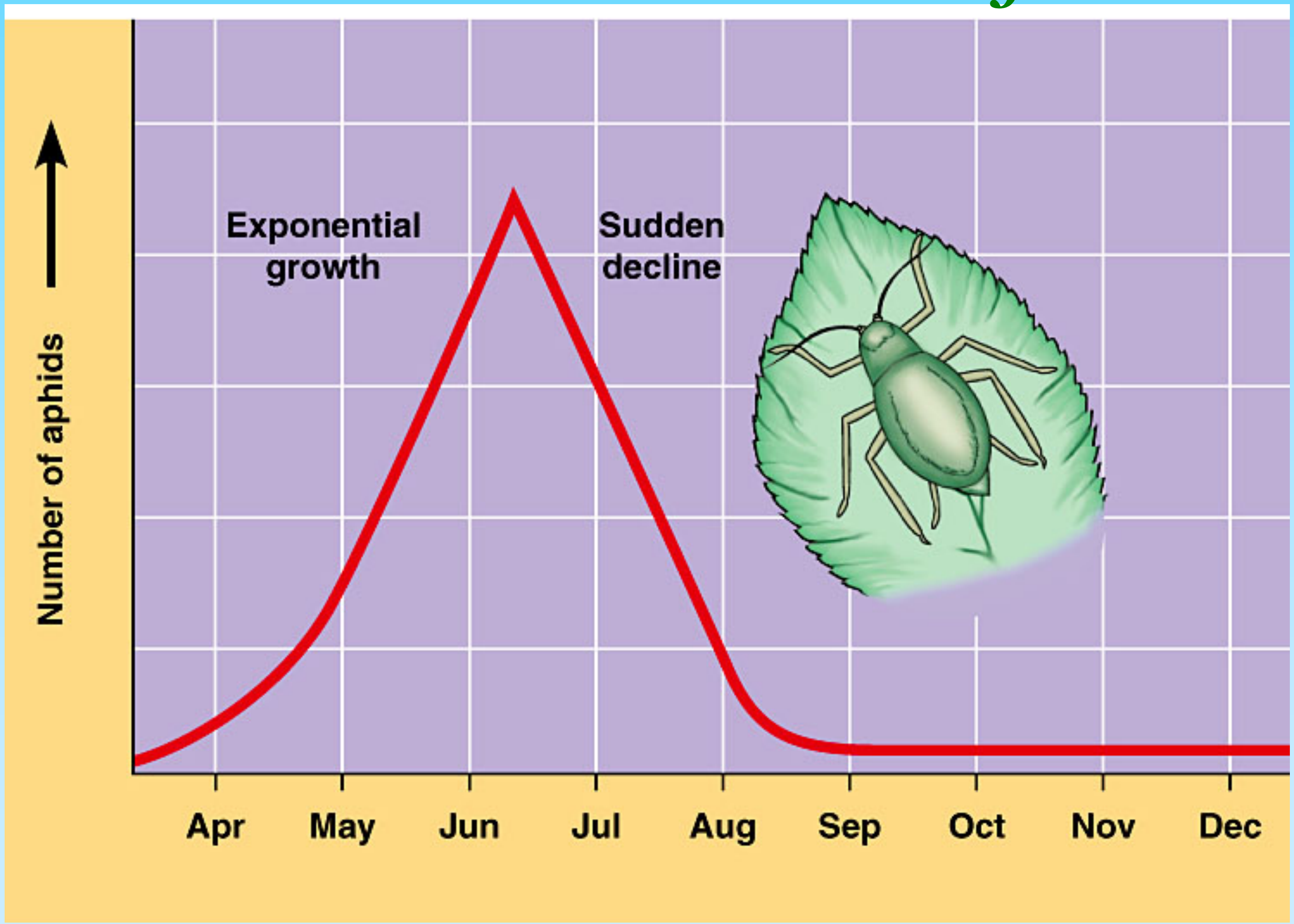


Four phases:

1. **Lag** – slow; not enough reproducing organisms
2. **Growth** - exponential
3. **Stationary** - natality = mortality
4. **Death** - decline (Not always present)

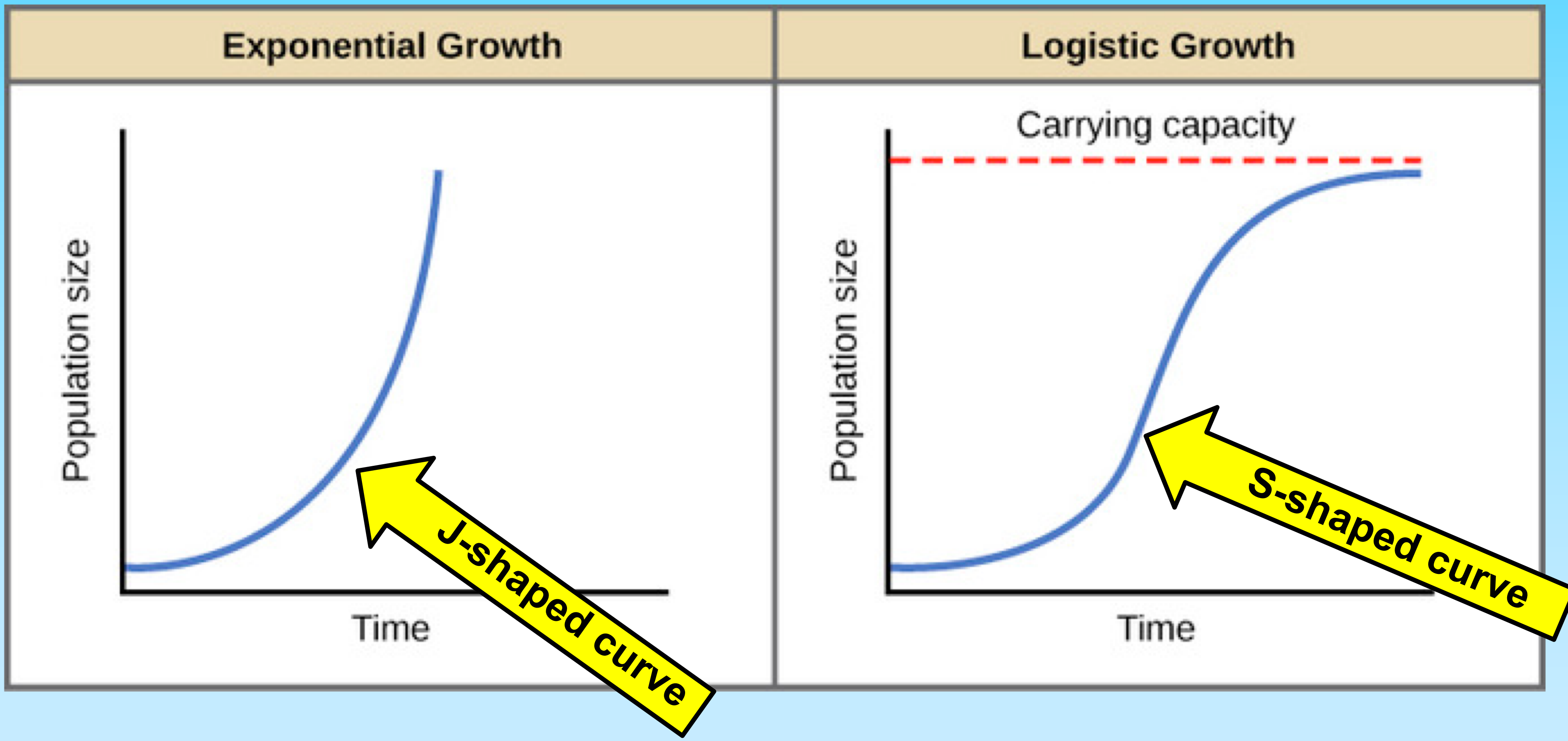
J- Curve Example

–*Aphids show exponential growth in the spring and then rapidly die off when the climate becomes hot and dry in the summer*



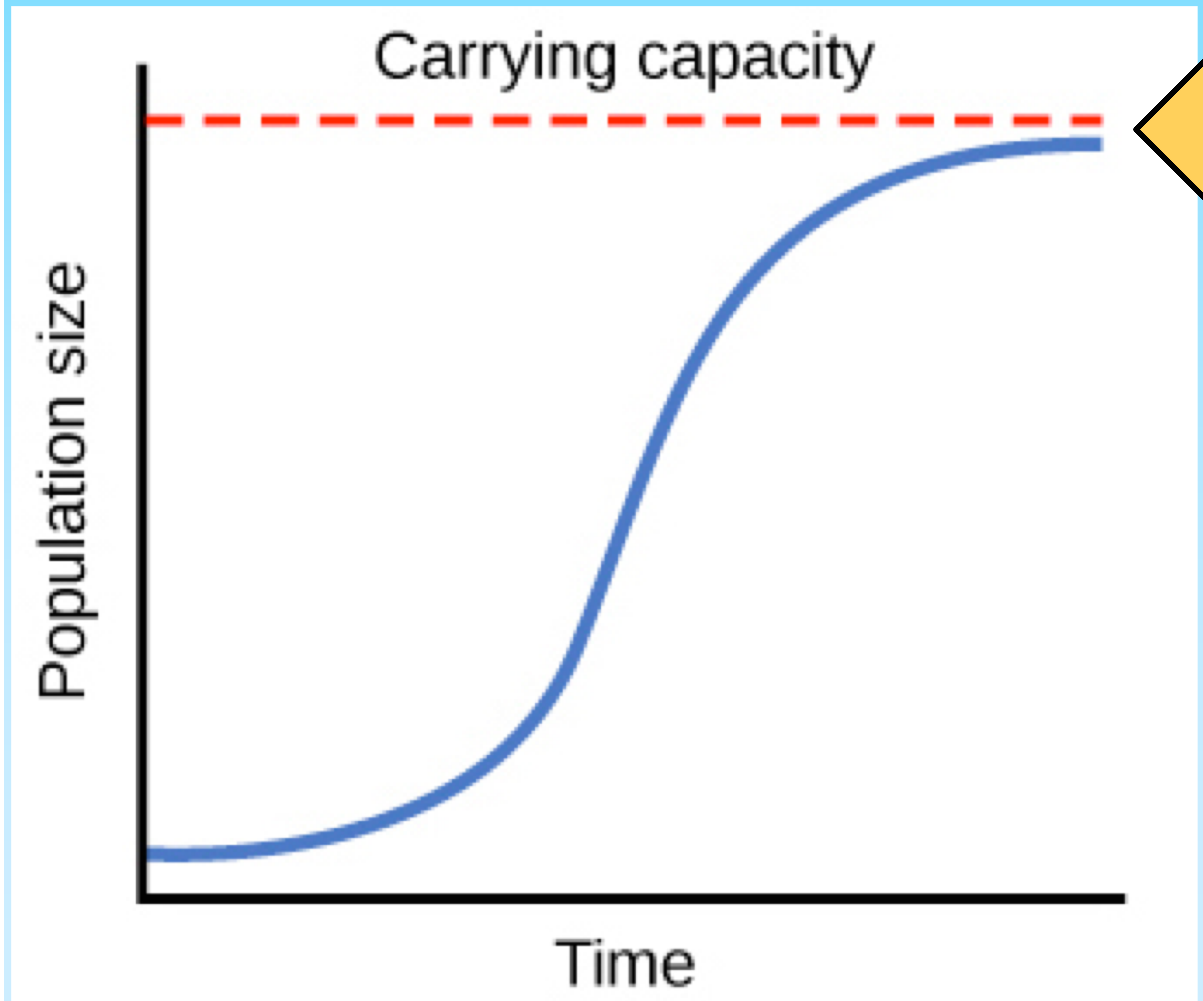
VIDEO: Aphids: Weird Poop, Weirder Babies

Growth Curve Characteristics



Carrying Capacity:

The maximum number of individuals an environment can support.



After rapid growth the curve **levels off**.

Growth Curve for Open Systems

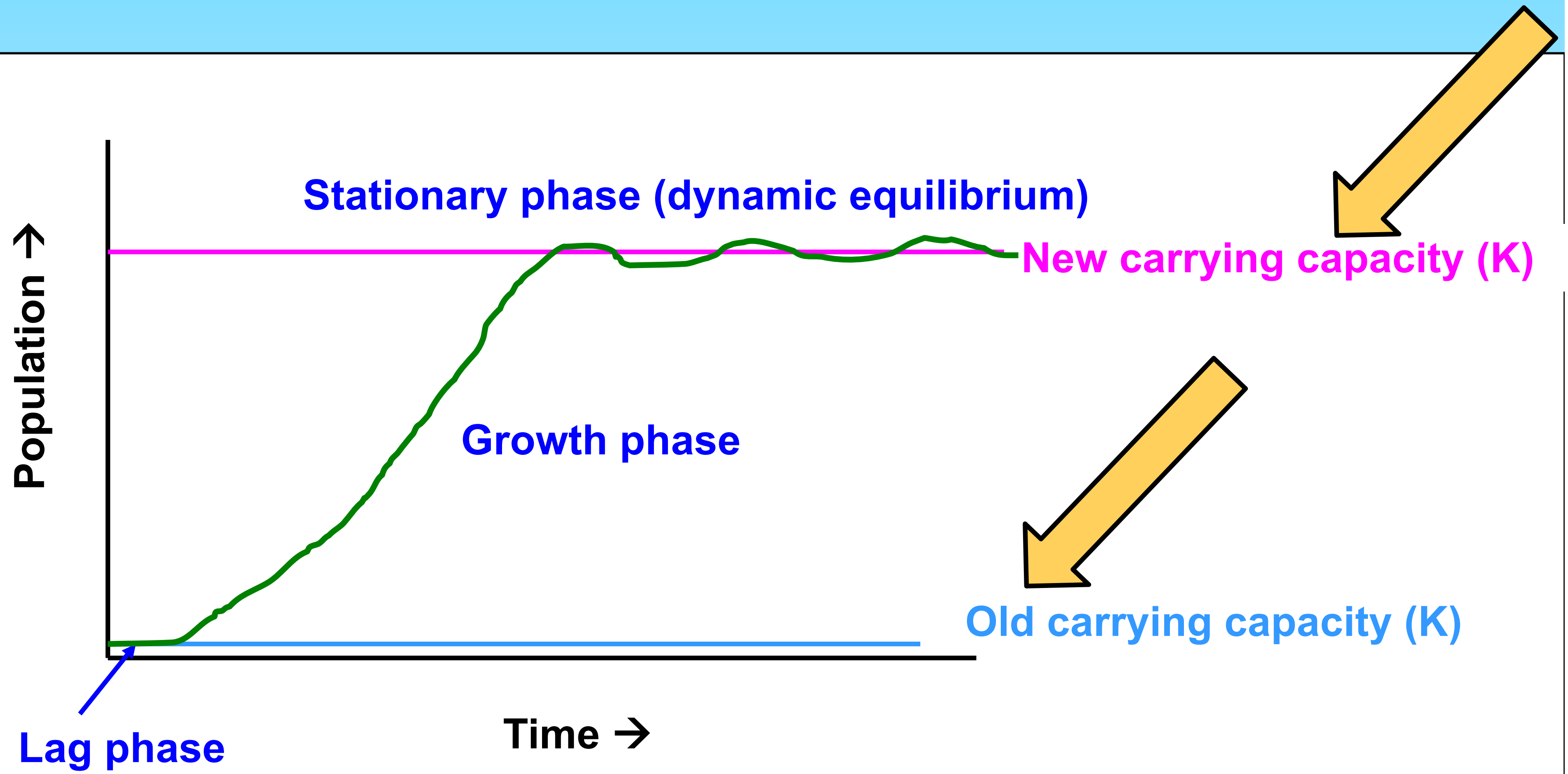
-LIMITING FACTORS (limited food, water, temperature changes, space, etc…) impact on a population curve results in an "S" shape

- Typical of K-selected species
- As organisms respond to increased nutrients, natality increases.
  - Equilibrium is established again and curve levels off
- New carrying capacity is reached

OPEN population growth curve,

Logistic also known as S-Shaped Growth Curve

If available resources are increased the carrying capacity will also increase to a new carrying capacity



"J-shaped" Growth Curves	vs.	"S- shaped" Growth Curves
▪ Rapid exponential growth → Rat ▪ r-selected species ▪ Show mass extinction events as resources are exhausted ▪ Mostly found in **closed** systems ▪ Normally unsustainable in nature		▪ Logistic growth → Kangaroo ▪ K-selected species ▪ Slowly level off due to competition for limited resources – **dynamic equilibrium** ▪ Mostly found in **open** systems

Growth Curve for Open Systems

Open population growth curves represent the dynamic equilibrium that is a result of the balance between:

1. **Biotic potential (stable)**

(maximum natality under ideal conditions)

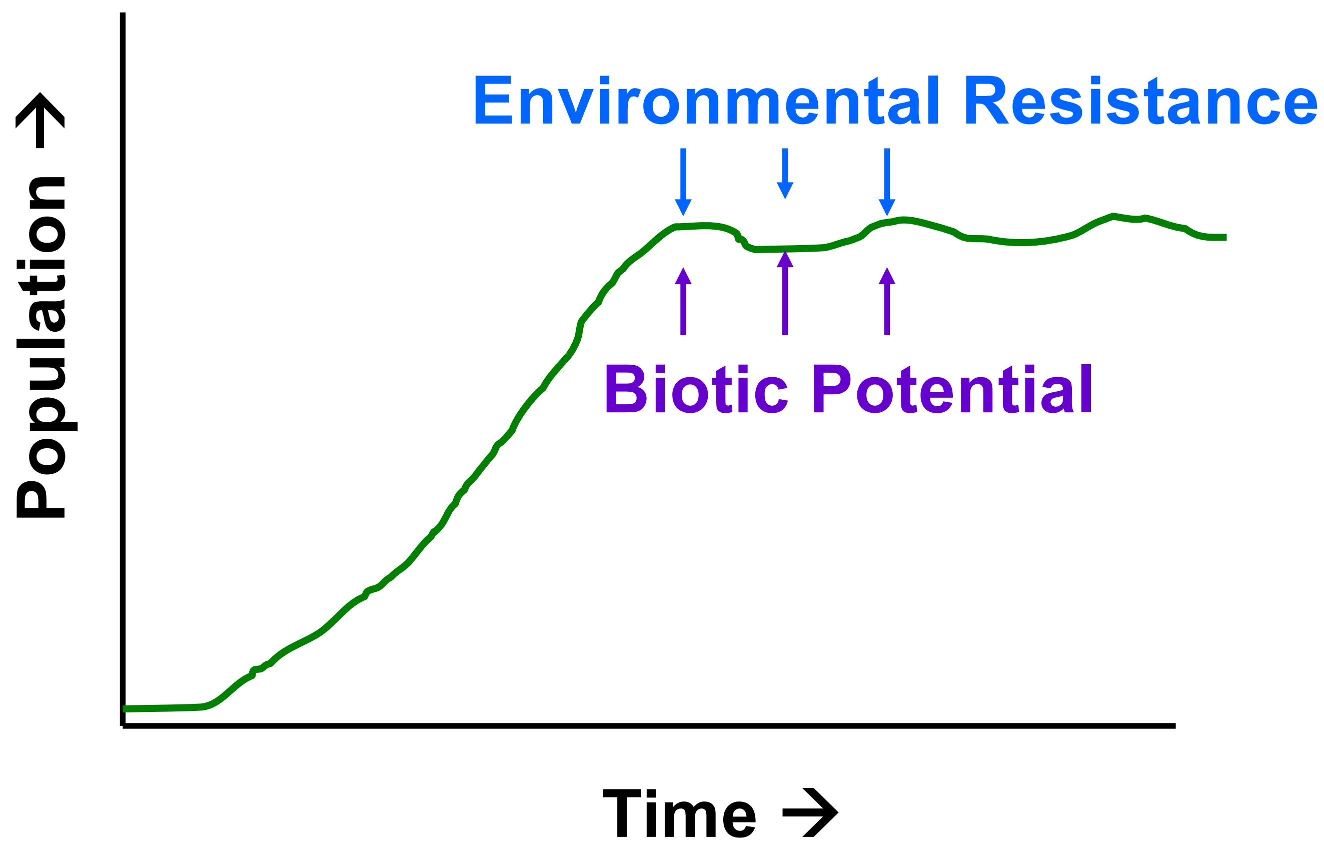
and

2. **Environmental Resistance**

(biotic and abiotic factors that limit growth)

Open Population Growth Curve

(S-Shaped Growth Curve or Logistic Growth Curve)



Biotic Potential

Maximum number of offspring produced in ideal conditions.

Regulated by:

1. **offspring** - max # of individuals born / birth
2. **survival capacity** – chance that offspring will reach reproductive age
3. **procreation** - # times / year organism reproduces
4. **maturity** - age when reproduction begins

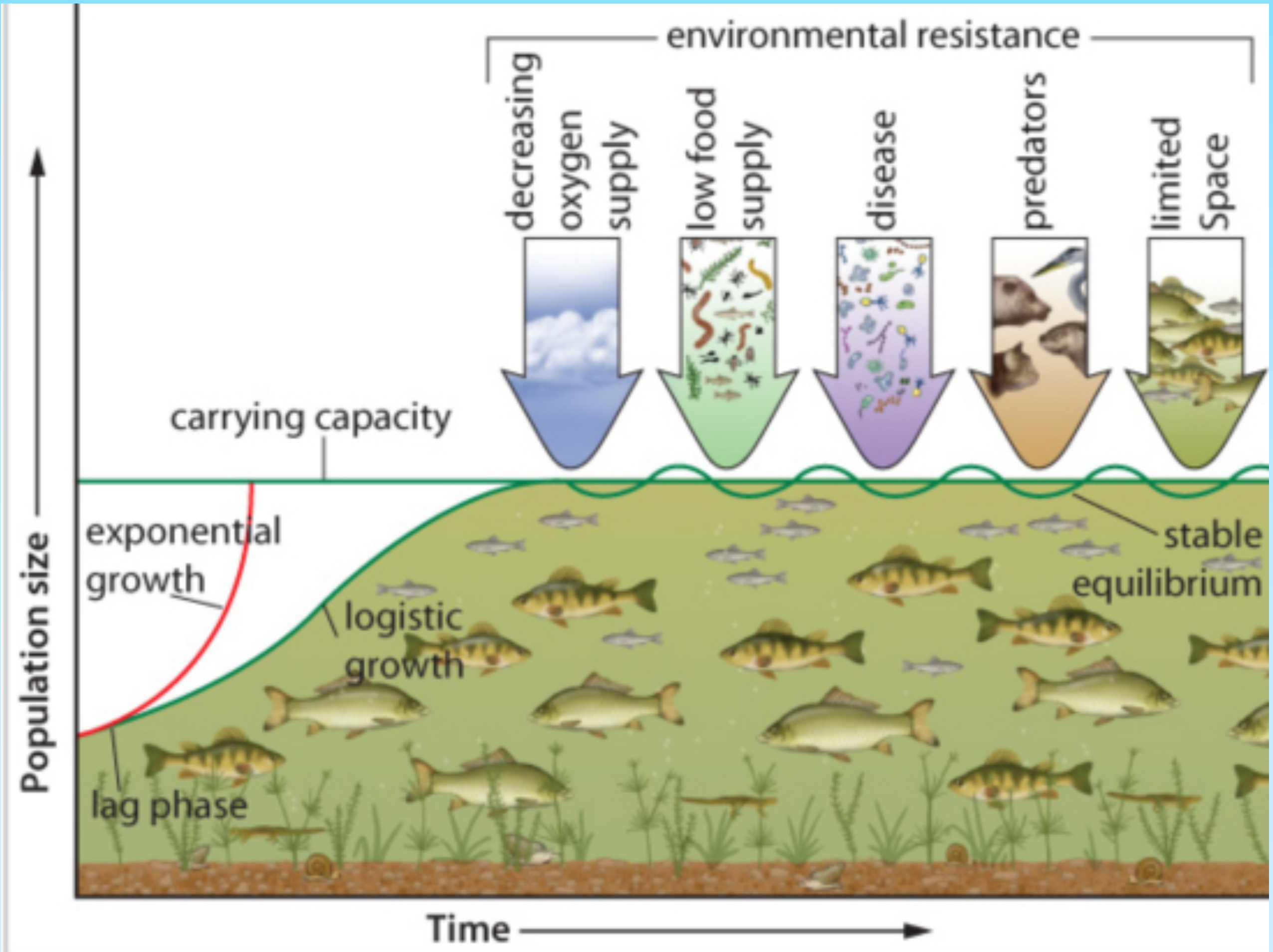
Environmental Resistance

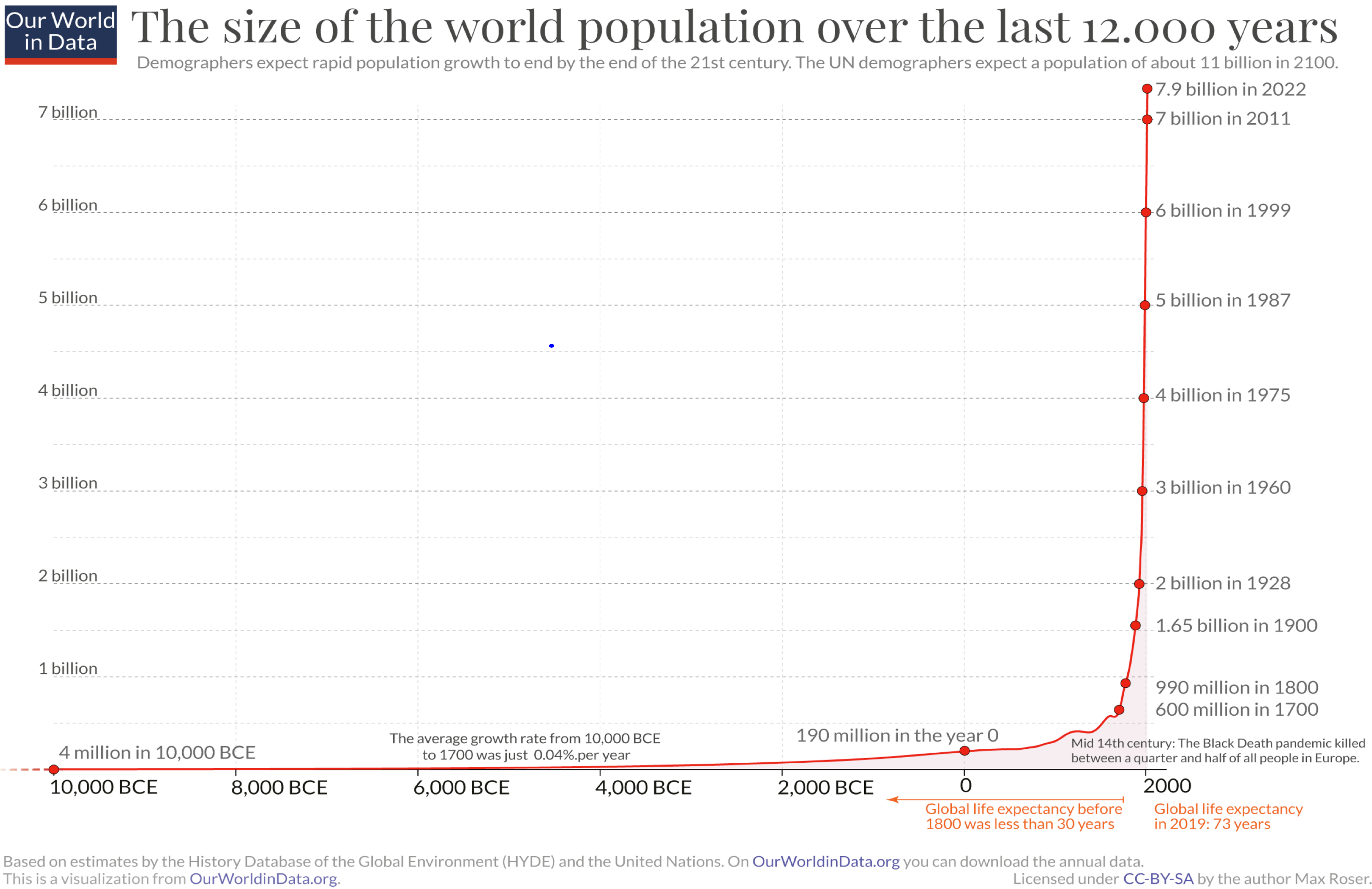
All factors that limit population growth

- **Biotic (living)** – food, disease, predation, availability of mates

OR

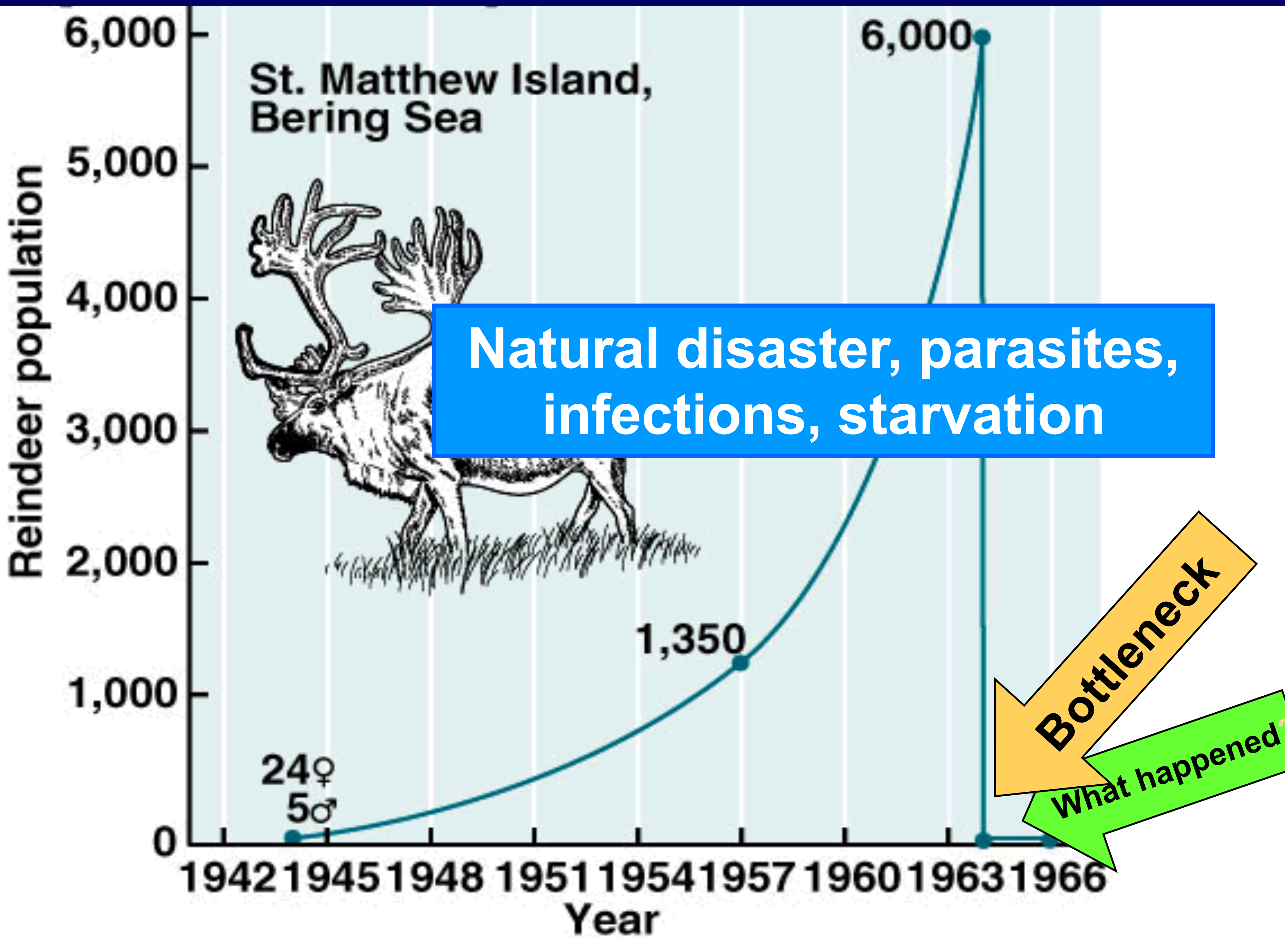
Abiotic (non-living) – water, space, natural disasters, sunlight



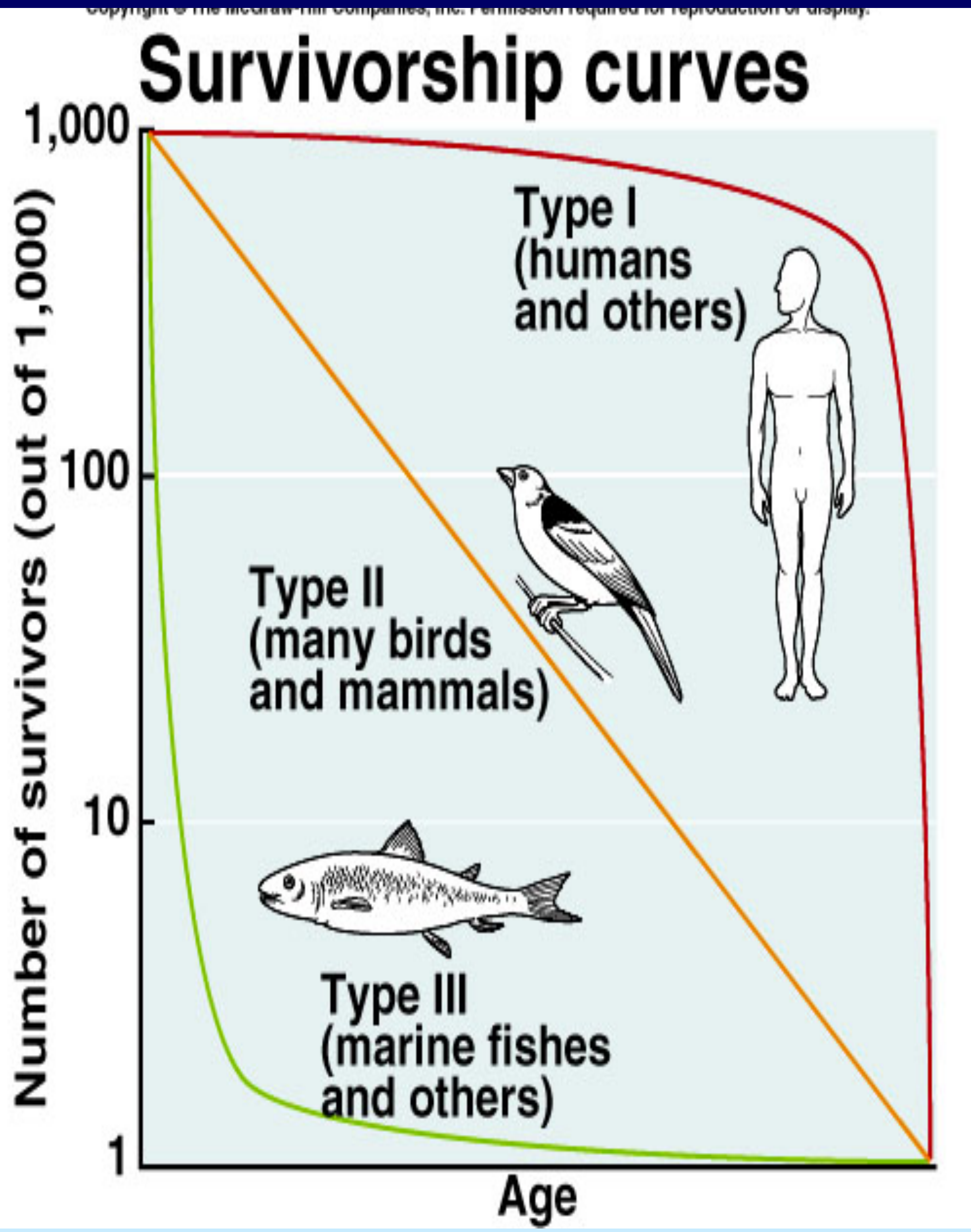


How does the population growth rate compare 2000 years ago with now?

Population Explosion & Crashes



What information can you gather from this graph?



1. Which species numbers decrease rapidly at a young age?

Fish

2. Which species tend to live the longest?

Humans

3.Give two reasons for this:

Humans have no predators.

Humans care for their young.

Humans have only 1 or 2 offspring to look after.

Humans have health care.

Limiting Factors

- Affect population size
  - flood, fire, extreme cold, disease, starvation, predation

Law of the Minimum

- the substance with the lowest concentration will limit growth (known as limiting factor)
- -eg. Water, food, space

Limiting Factors can be classified as:

1. Density Dependent:

- Severity is dependent on population size
  - i.e. bacteria spreads faster in more dense populations
  - i.e. food harder to find with more individuals
- BIOTIC limiting factors
  - disease, starvation, predation

2. Density Independent:

- affects population regardless of # of individuals
- ABIOTIC limiting factors
  - flood, fire, extreme cold…

Density Dependent vs Density Independent

DD or DI?

- __DI__1. Freezing weather
- __DD__2. Has a greater effect on a larger population
- __DI__3. A volcanic eruption
- __DD__4. Predation
- __DI__5. Floods
- __DD__6. Food supply
- __DI__7. May limit the population before it even gets close to carrying capacity
- __DD__8. Disease or parasites \
- __DD__9. Decreases when the population is below carrying capacity; increases when the population exceeds carrying capacity
- __DI__10. Fire
- __DI__11. Intensity of effect no greater for larger population, no less for smaller population
- __DD__12. May cause cyclical changes in lynx and hare populations
- __DI__13. Storms
- __DD__14. Tends to be a biotic factor
- __DI__15. Tends to be an abiotic factor

Brainstorm

Brainstorm

	▪ Characteristics of **R**ats in regards to Population growth	Characteristics of **K**angaroos in Regards to growth
Number of births per year	**Many**	**Few**
Number of offspring in each birth	**Many**	**Few**
length of life	**Short**	**Long**
caring of offspring	**Short**	**Long**
Time till reproductive maturity	**Short**	**Long**

Populations can be classified as K-selected or r-selected

K - selected

- Long life span
- Late reproductive age
- Low reproductive rate
- Few offspring
- Require parental care
- Large individuals
- near carrying capacity (K)
- Predictable envionments
- Ex. Deer, bears, moose

r - selected

- Short lifespan
- Early reproductive age
- High reproductive rate
- Many offspring
- Require little or no parental care
- Small individuals
- Rapidly changing enviornments
- Ex. Bacteria, insects, rodents

K-strategists

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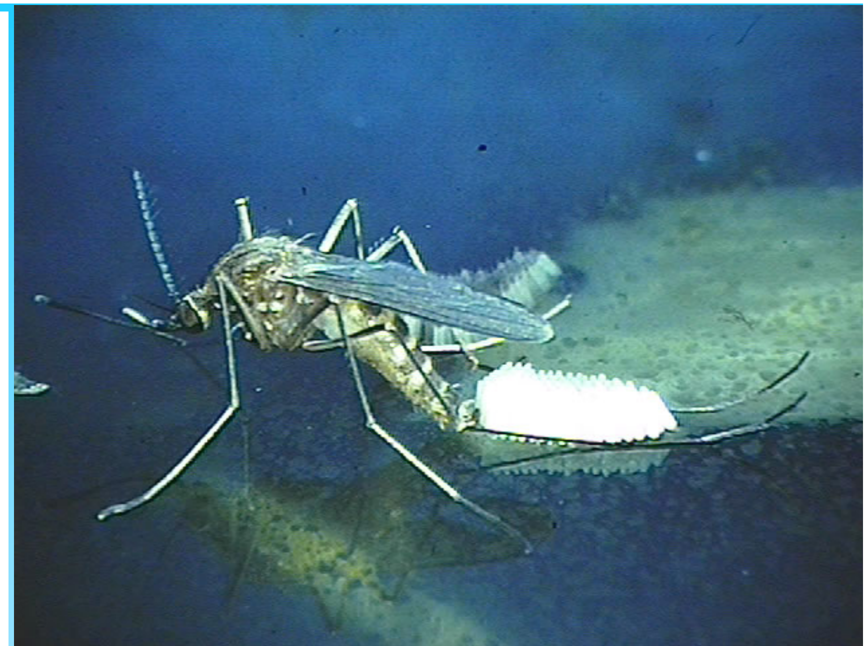
_K_-strategists

- Large individuals
- Long life span
- Slow to mature
- Few offspring
- Much care of offspring

r-strategists

r-strategists
Small individuals Short life span Fast to mature Many offspring Little or no care of offspring

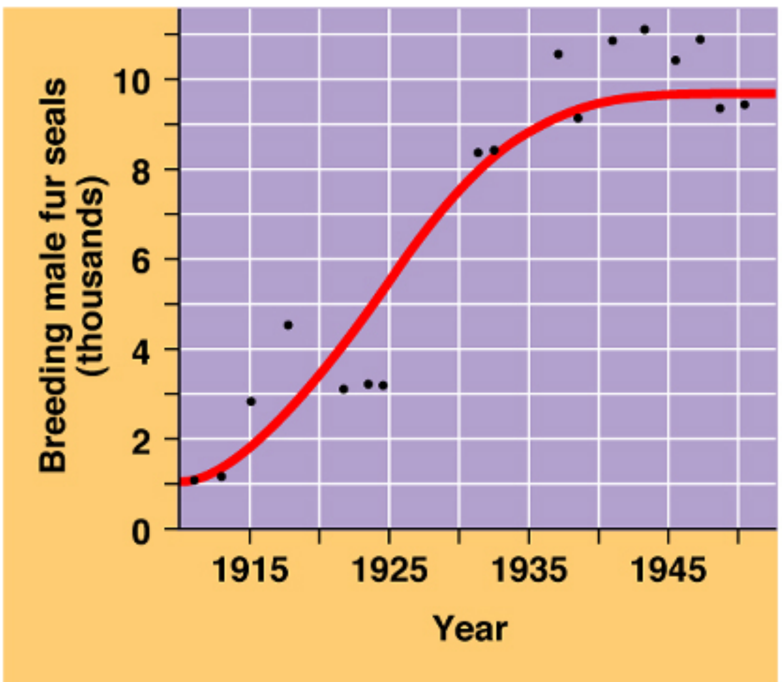


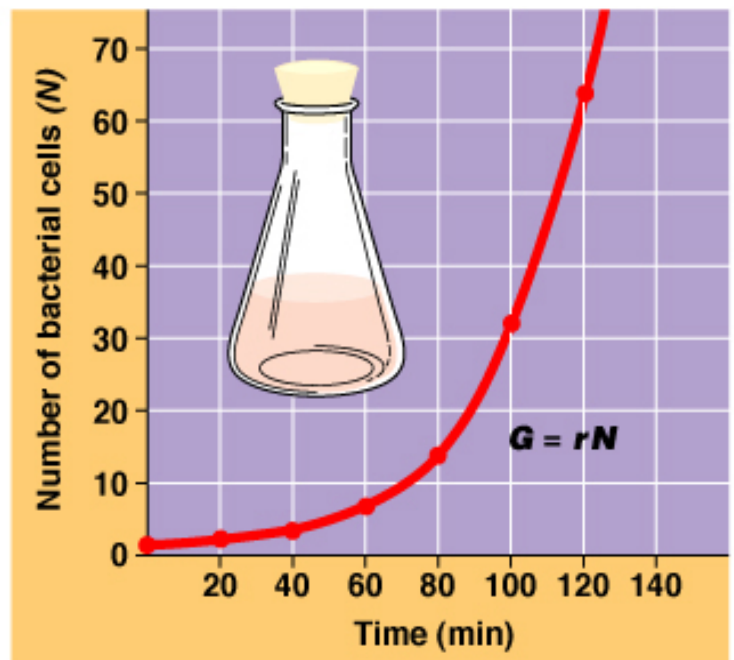
K-selected species species

- Tend to have an S-shaped growth curve: **logistic growth pattern**

r-selected

- Tend to have a J-shaped growth curve: **exponential growth pattern**





- Workbook: pages 7(right), 8, 9