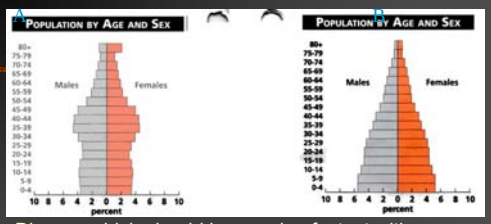
Source: Population Reference Bureau and National Audubon Society



- Discuss which should be growing fastest with a neighbor
- Revise your answer if necessary
- Briefly characterize the two groups (e.g., survivorship, population growth rate, expected income, geographic location, names, etc).

Age structure assignment -10 pts, Due March 5

- Go to http://www.census.gov/ipc/www/idb/pyramids.html Get and print (or sketch) age structures for two different countries that interest you
- For each country
  - Compare age structure in 2000 to that projected for 2050
  - Compare population sizes in 2000 to 2050
  - Characterize the country in terms of being third world, war ravaged, etc.
- Compare the age structures and rate of increase of the two countries and attempt to explain differences between them

Visit census bureau

- http://www.census.gov/ipc/www/idb/pyramids.html

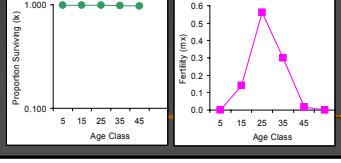
Muddy points for Chapter 11 Spring 2009

- Life Tables (2)
- Geometric /Pulsed Growth (3)
- Exponential Growth (6)
- Geometric vs. exponential growth (**11**)
- Equations (8)
- Logistic Model of Growth (**17**)
- Carrying Capacity and Limits to Growth (5+ 4)
- Causes of density dependent growth (3)
- Human population growth (3)

Combining survivorship and fecundity

- Life tables.
  - Table of l_x and m_x
  - Allow projections of population dynamics

age group	l_x	m_x
0-9	0.993	0.000
10-19	0.992	0.140
20-29	0.987	0.563
30-39	0.981	0.300
40-49	0.968	0.018
50+		0.000



Combining survivorship and fecundity

- Important summaries of a life table are:
  - R_0 (net reproductive rate)
  - T (Generation time)
  - r (per capita rate of increase)
- In many cases, ignore males
  - Counts are of females
  - Births are of female offspring

R_0 = Net Reproductive Rate

- Average number of offspring left by each female
- Can calculate from survival and fecundity for each age class
- $R_0 = \Sigma(l_x m_x)$

age group	l_x	m_x	$l_x m_x$
0-9	0.993	0.000	0.000
10-19	0.992	0.140	0.139
20-29	0.987	0.563	0.556
30-39	0.981	0.300	0.294
40-49	0.968	0.018	0.017
50+		0.000	0.000
		1.021	1.006

T = Generation time

- Average time from being an egg to laying an egg (being a baby to having a baby)
- Calculate from the timing of births and deaths
- $T = \Sigma(x l_x m_x) / R_o$
  - X is the midpoint of the age class
    - Annuals: annual, x=1, and T=1
  - Perennials: x varies with age class

age group	x	l_x	m_x	$l_x m_x$	$x l_x m_x$
0-9	5	0.993	0.000	0.000	0.000
10-19	15	0.992	0.140	0.139	2.083
20-29	25	0.987	0.563	0.556	13.892
30-39	35	0.981	0.300	0.294	10.301
40-49	45	0.968	0.018	0.017	0.784
50+			0.000	0.000	0.000
			1.021	1.006	27.060

T	26.9
$=\Sigma(x l_x m_x) / R_o$	

r (per capita rate of increase)

- Overall birth rate – overall death rate
- $r = \ln(R_o) / T$
  - ln is the natural logarithm
- Critical Values
  - r > 0: grow
  - r < 0: shrink
- In this case (US 1998), r= 0.02%/year

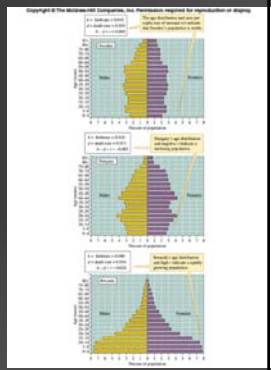
R_o	1.006
$=\Sigma(l_x m_x)$	
T	26.9
$=\Sigma(x l_x m_x) / R_o$	
r	$=\ln(R_o)/T$ 0.00023

Life Table – see spreadsheet

age group	mid point age	Proportion surviving to this age	# female offspring / female / 10-years		
x		l_x	m_x	$l_x m_x$	$x l_x m_x$
0-9	5	0.993	0.000	0.000	0.000
10-19	15	0.992	0.140	0.139	2.083
20-29	25	0.987	0.563	0.556	13.892
30-39	35	0.981	0.300	0.294	10.301
40-49	45	0.968	0.018	0.017	0.784
50+			0.000	0.000	0.000
			1.021	1.006	27.060

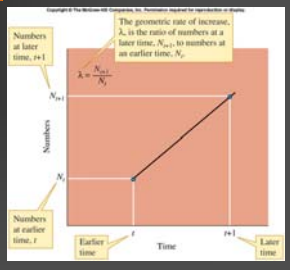
S.A.D.

- IF l_x and m_x stay constant, a population will eventually reach a STABLE AGE DISTRIBUTION.
- Each bar will be a constant proportion of the bar above it



λ (Geometric Rate of Increase)

- Ratio of the population sizes at two different times
- $\lambda = N_{t+1} / N_t$
  - If N_t = 1, and N_{t+1} = 2,
    - then λ = 2
    - Population will double
- Critical Values:
  - λ >1: grow
  - λ <1 shrink
- Most appropriate when growth occurs in 'pulses'
  - E.g., Yearly breeding season (deer, bears, annuals)



Conclusions

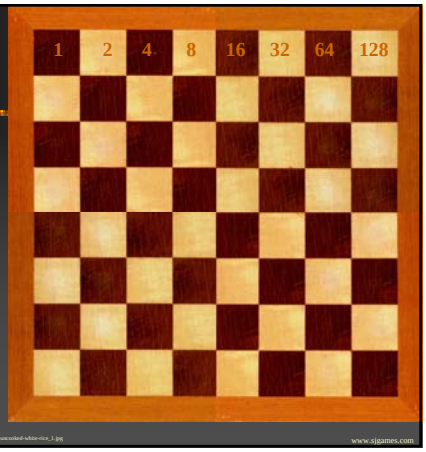
- A survivorship curve summarizes the pattern of survival in a population
- Patterns of births in a population can vary from semelparous to interoparous
- Age distribution reflects the history of survival, reproduction, and the potential for future growth of a population
- A life table (l_x and m_x) can be used to estimate net reproductive R_0 (net reproductive rate), λ (Geometric rate of increase), T (Generation time), and r (per capita rate of increase)

The parable of the grain of rice

- Prince rewards the inventor of chess
- The inventor asks for "one grain of rice" on the first square of the chessboard
  - 2 on the second
  - 4 on the third,
  - And so forth for all 64 squares
- Was this a reasonable reward?
  - A) Yes
  - B) No
- (How much rice will the prince give out?)

www.sjgames.com

Doubles each square



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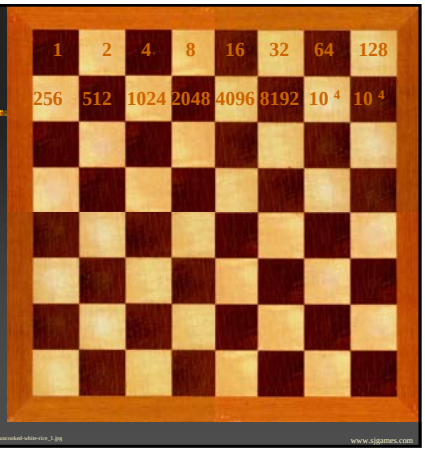
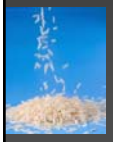
Doubles each square





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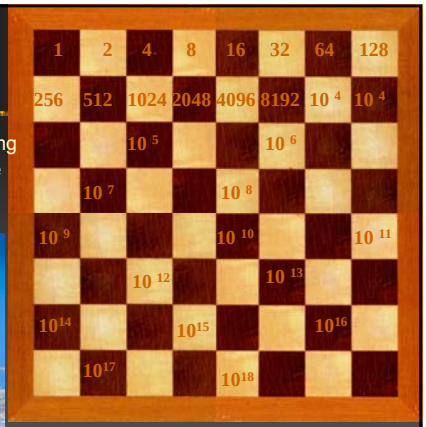
Doubles each square

- One grain =25 mg
- Halfway (square 32): 100,000 kg



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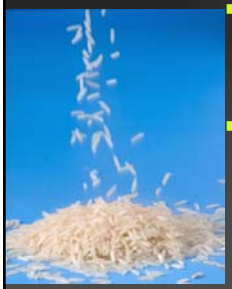
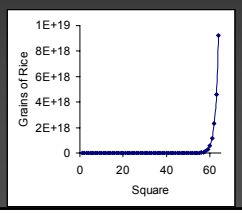
Doubling 64 times

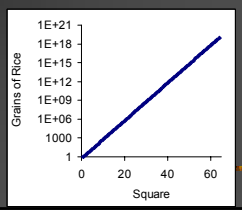


- On the 64th square: 9,223,372,036,854,780,000 grains (2^{63})
  - At 25 mg/grain = 2 billion tons
- Total for 64 squares is 4 billion tons
  - Global rice production in 2008: ~ 30 million tons

Living things multiply

- With additive growth, the inventor would have 1+1+1… = 2,080 grains = 5.2 grams
- With multiplicative growth, 4 billion tons





The Careers assignment …

- How valuable was the assignment to you?
  - A) Enormously valuable
  - B) Very Valuable
  - C) Helpful
  - D) Not very helpful
  - E) A waste of time
  - F) Other

The Careers Assignment

- The amount of work required for this assignment was:
  - A) Way Too Much
  - B) Too Much
  - C) About Right
  - D) Not very much
  - E) Way too little

The Careers Assignment…

- Next year this assignment should be:
  - A) repeated exactly as it was this year
  - B) Used again, but slightly revised
  - C) Used again, but with major revisions
  - D) Maybe used again, but with major revisions
  - E) Dropped

Geometric, exponential, and the difference between them

- Go to board