



## Module 2: Population



» One female cockroach can produce up to 80 eggs every 6 months...

Source: Figure 3.17 of textbook

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## Population Growth - Exponential

$$\frac{dN}{dt} = rN \text{ in textbook}$$

change in number

change in time

$$\frac{dN}{dt} = (r - 1)N \text{ correction}$$

rate of growth  
(as defined in text)

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## Population Growth - Exponential

Exponential Growth Equation  
("biotic potential" for unlimited growth)

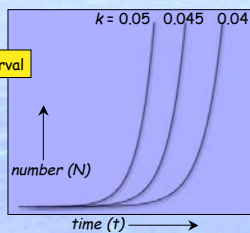
future population

growth rate as a decimal

$$N = N_0 e^{kt}$$

time interval

current population



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### Population Growth - Exponential

Exponential Growth Equation  
("biotic potential" for unlimited growth)

Example

The current population of cockroaches is 14.9 million and is growing at a rate of 2.9% (which means  $k = 0.029$ ). What will the cockroach population be after 5 years?

$$N = N_0 e^{kt}$$

$$N = (14.9 \times 10^6) e^{(0.029 \times 5)}$$

$$N = (14.9 \times 10^6) * 1.156 = 17.2 \times 10^6$$

$N = 17.2$  million

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### Population Growth - Exponential

Exponential Growth - "J-curve"  
("biotic potential" for unlimited growth)

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### Population Growth - Oscillatory

Some species exhibit a pattern of cyclic "overshoot" and "dieback"

overshoot

dieback

Carrying Capacity = maximum population that an environment can sustain indefinitely

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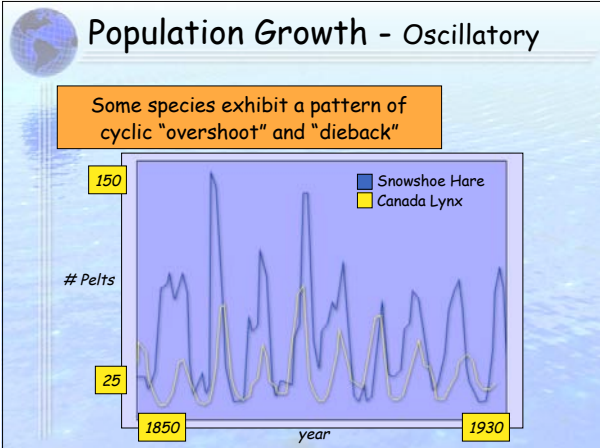
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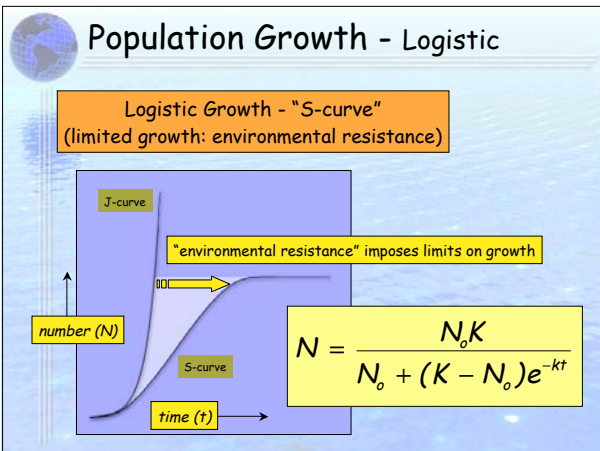
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## Population - History

- » Every 3 years the world's population grows by about the size of the U.S. - 280 million every 3 years - 93 million per year - 255,000 every day - or about 3 people every second.
- » 98% of growth is in developing countries
- » Pakistan - fewer than 40 million people in 1950 will overtake the U.S. by 2050 for 3rd place overall... Nigeria is projected to triple its population by 2050 and be in 5th place

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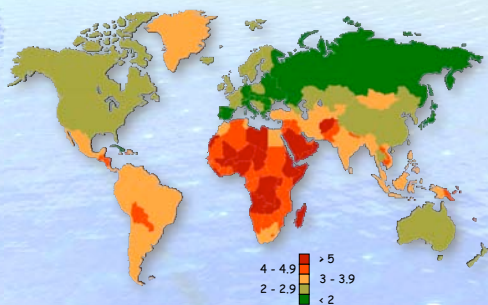
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## Population - Fertility Rates

(average # children in woman's lifetime, 15-49)



Source: UN Population Division - 2000

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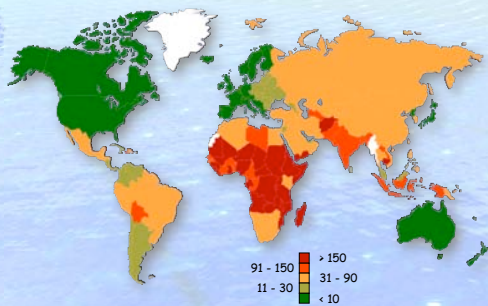
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## Population - Infant Mortality

(deaths before age 1 per 1000 live births)



Source: UN Population Division - 2000

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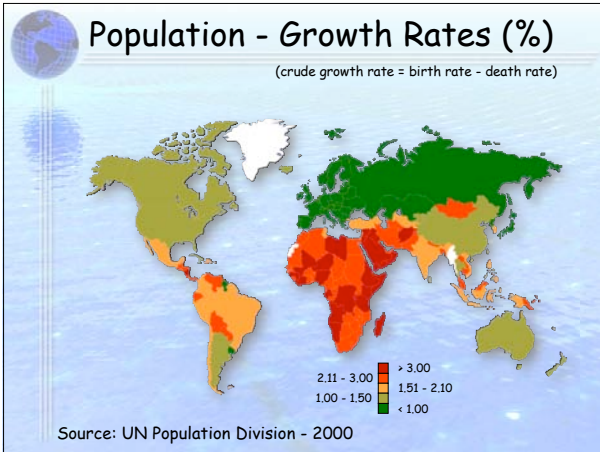
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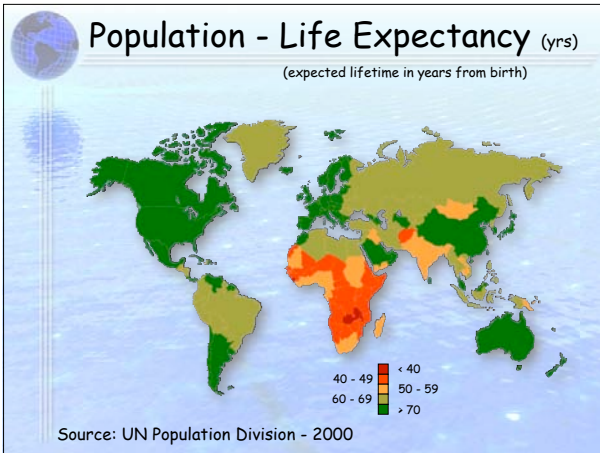
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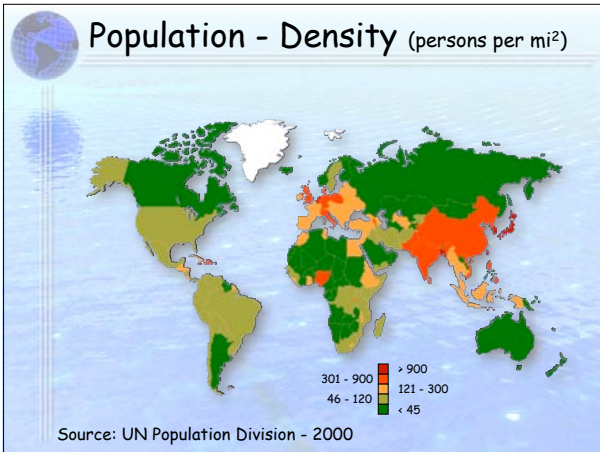
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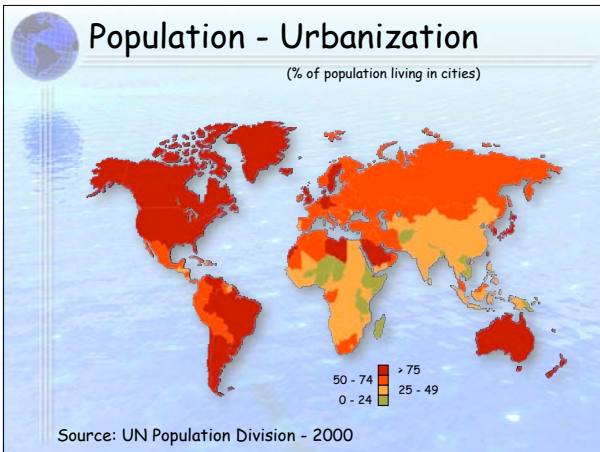
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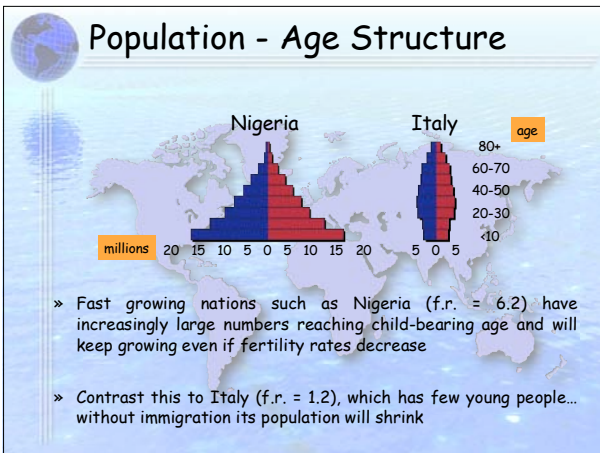
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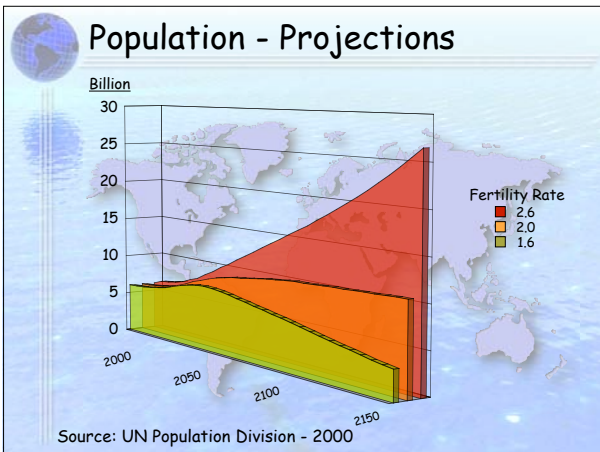
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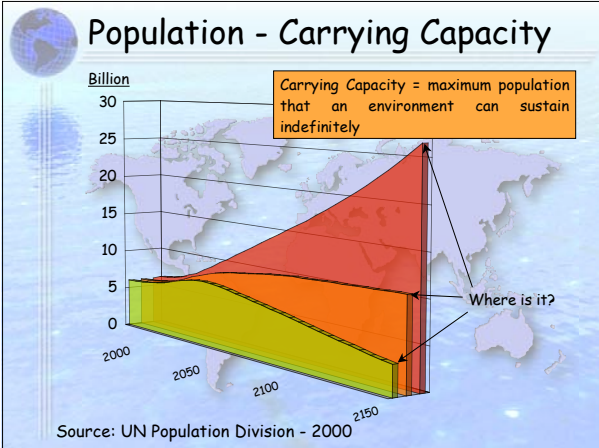
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### Population - Predicting the Future

- » In general, populations grow logistically, which we can think of as exponential growth at variable rates
- » Exponentially means a pattern similar to the series: 1, 2, 4, 8, 16, ...

**EXAMPLE** Take an 8-1/2" x 11" piece of paper and begin folding it in halves... you can probably fold it in half at most about 8 times. If you could fold it in half say 42 times, how thick do you think the paper would be?

**IT WOULD STRETCH FROM HERE TO THE MOON!**  
(Distance to the moon is about 240,000 miles; piece of paper is about 0.0035" thick. Try to determine this for yourself.)

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### Population - Predicting the Future

- » The time it takes for a population to double is called the "doubling time"
- » It is given by the equation:  $d.t. = \frac{70}{\% \text{ rate}}$

**EXAMPLE** The money in your retirement account behaves exactly the same way as population. If you invest \$1,000 at an interest rate of 14%/year, how long does it take for your money to double to \$2,000?

The time it would take to double to \$2,000 is the *doubling time* and is equal to 70 divided by 14 = 5 years.

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## Population - Some Doubling Times

	Growth Rate (%)	Doubling Time (yrs)
» Western Europe	0.1	$70/0.1 = 700$
» U.S.	0.6	$70/0.6 = 115$
» China	0.9	$70/0.9 = 77$
» World Average	1.3	$70/1.3 = 53$
» Chad	3.3	$70/3.3 = 21$

∴ As Growth Rate ↑ Doubling Time ↓

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## Population - Summary

- » Many things affect population growth: fertility rate, age structure, health care, economic conditions, political climate and culture are a few.
- » Populations grow exponentially/logistically (i.e. they start out slowly, then become rapid and finally slow down again)
- » Doubling time =  $70/(\% \text{ rate of growth})$
- » Carrying Capacity = maximum population that can be sustained indefinitely
- » Population problems place a heavy burden on ALL resources (air, water, soil)

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