We the people

- Total world population ____ billion
- Birth rate ____ births per 1,000 population
- Death rate ____ deaths per 1,000 population
- Rate of natural increase (birth rate-death rate) ____ % (doubling time: ____ years)
- Total fertility rate ____ lifetime births per woman
- Percent of population below age 15 years ____ %
- Percent of population age 65+ ____ %
- Life expectancy (total) ____ years
- Percent urban ____ %
- Percent of "married" women using modern contraception _____ %
- Population per square mile ____

Population growth – an epidemic of homo sapiens

Pre-historic times	< 10 million	hunter-gathers
8,000 B.C.	10 million	beginning of agriculture
1650 A.D.	500 million	Rennaisance, agricultural revolution, European colonialism
1800	1 billion	industrial revolution, vaccination
1930	2 billion	sanitation and public health, mass transit, mass production, mass media,
1975	4 billion	Public health for the developing world, Green Revolution, population movement
2000	6 billion	Information Age, computers & the Internet, biotechnology, globalism
2050	9 billion	Gene modification?

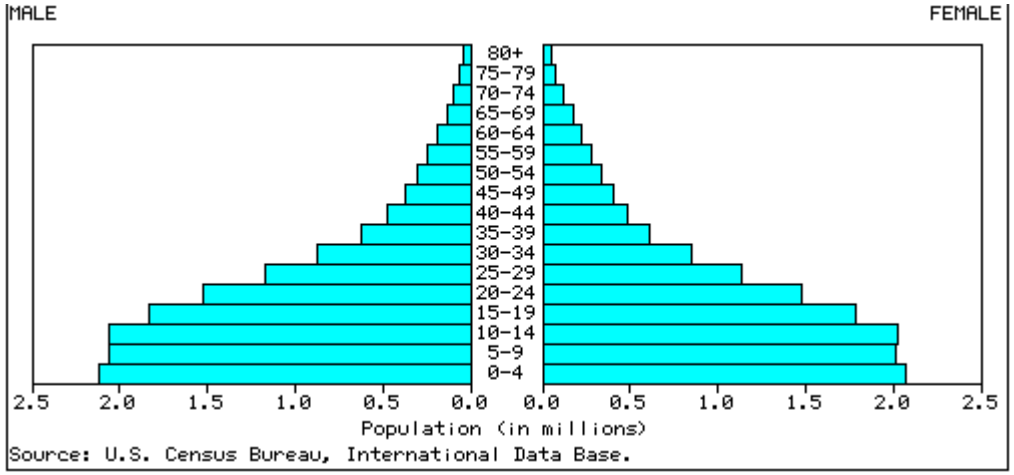
World Population in mid-2000 (millions) and growth rate, by region

Region	Population	Doubling time
Asia	3,684	48 yrs
South Central Asia – India, Bangladesh	1,475	37
East Asia – China, Japan, Korea	1,493	85
Africa	800	29 yrs
Europe	728	- yrs
Latin America & Caribbean	490	39 yrs
North America	345	124 yrs
Oceania (Australia, NZ, & Pacific)	31	65 yrs
World	6,067	51 yrs

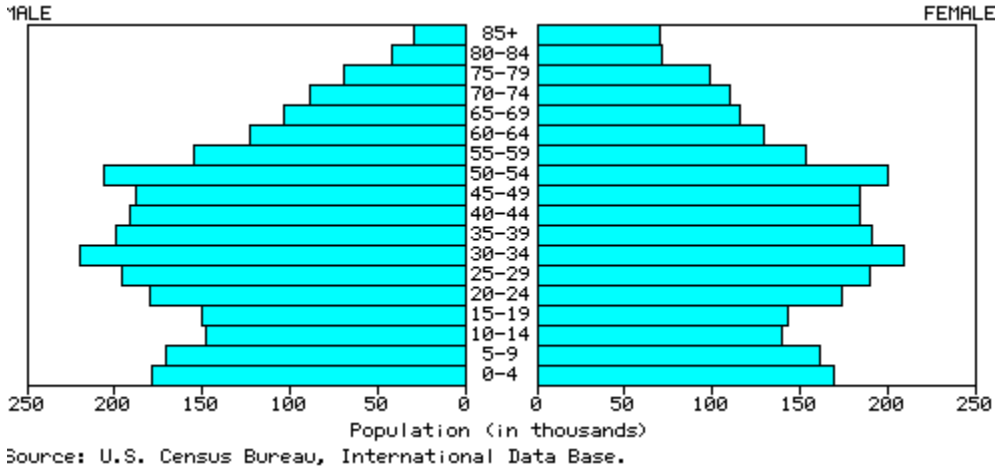
- 96% of world population growth takes place in the developing world.

Population growth and age structure

- Population growth → younger population → fertility ↑, mortality ↓
- Reduced population growth → aging population → fertility ↓, mortality ↑
- % of persons 60 years and older will grow from about 9% to 13-17%



Kenya, 1998



Denmark, 1998

- Average age of the world's population is projected to increase from 28 yrs to 31-35 yrs
- % of persons 60 years and older will grow from about 9% to 13-17%
- 2030 projection: 5% in sub-Saharan Africa, 20% in China, 30% in Western Europe

Influence of population age composition

When the baby boom cohort retires

	1995	2030
Retired population (%)	12	20
Workers per retired person	3.4	2.0
Combined Social Security and Medicare tax rate per worker (including employer's share)	15%	28%

(Source: Who will pay for your retirement? The looming crisis. Center for Economic Development, NY, NY. Summarized in TIAA-CREF quarterly newsletter *The Participant*, November 1995: 3-5.)

Sex composition

- Sex ratio: the number of males per 100 females
- Affected by war, migration, cultural preferences, differential mortality rates, incarceration
- Birth rate changes with the tendency for women to marry older men can produce an imbalanced sex ratio for potential mates
- Societal treatment of women is a key factor in birth rates and sex ratios

Racial, ethnic, and religious composition

- "Race" (a social/political classification generally based on physical characteristics) is a force in society though not a meaningful biological construct, ethnicity (generally defined in relation to cultural characteristics), and religion are related to beliefs, values, practices, and societal treatment. Conflicts related to race, ethnicity, and religion have been a major phenomenon throughout the world and throughout history.

Birth rate, fertility rate, and fecundity

- **Birth rate** – births during a stated period divided by population size (per 1,000)

$$\text{Birth rate} = \frac{\text{Births during year}}{\text{Mid-year population}} \times 1{,}000$$

- **Fertility rate** – births during a stated period divided by population size (per 1,000)

$$\text{Fertility rate} = \frac{\text{Births during year}}{\text{Women of reproductive age (mid-year estimate)}} \times 1{,}000$$

- **Fecundity** – biological ability to have children

Total fertility rate (TFR)

- Summarizes age specific fertility rates by projecting their implications for a hypothetical cohort of women during their fecund years

Age	Births	
15	110	
16	110	
17	110	(average annual fertility
18	110	from ages 15-19 = 110/1000)
19	110	
20	180	
21	180	
22	180	(average annual fertility
. . .		from ages 20-29 = 180/1000)
29	180	
30	80	
31	80	(average annual fertility
. . .		from ages 30-45 = 80/1000)
44	80	
45	80	
	3,630	3.6 children / woman

(This TFR could also be calculated more compactly as:

$$110 \times 5 + 180 \times 10 + 80 \times 16 = 3{,}630)$$

Death rates

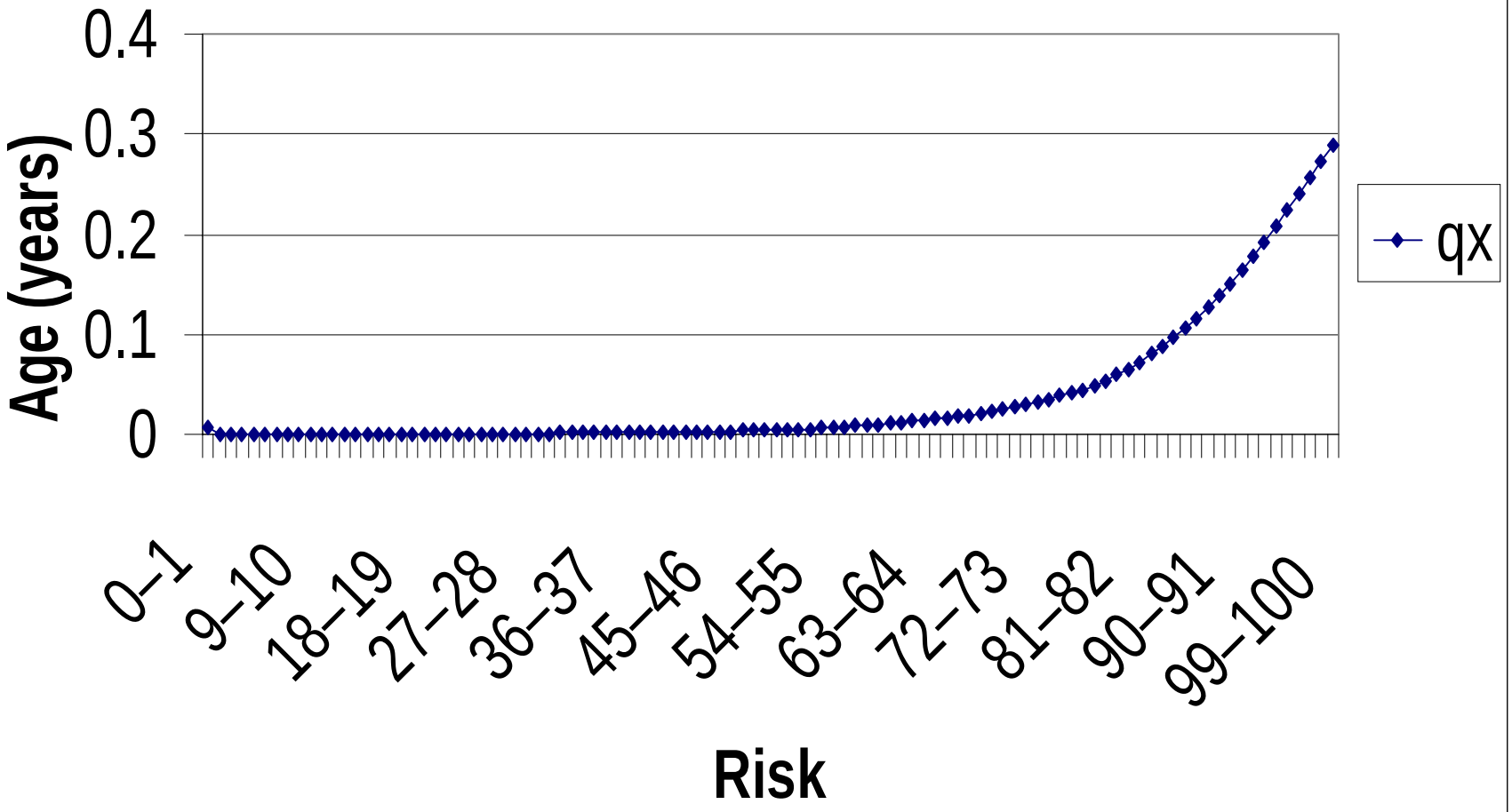
- **Death rate** – deaths during a stated period divided by population size

$$\text{Death rate} = \frac{\text{Deaths during year}}{\text{Mid-year population}} \times 1{,}000$$

- Average over several years if need more precision
- Use midyear population if growing (declining) steadily

$$\text{5-year average death rate} = \frac{\text{Deaths during 5 years}}{\text{Mid-year population in 3rd year}} \times 1{,}000$$

Risk of death by year of age, US, 1997



Life expectancy

- Demographic summary measures versus predictions: if death rates continue to decline, most of us will live beyond our life expectancy.
- Younger cohorts are healthier than past cohorts?

Excerpt from a column prepared by the Social Security Administration and distributed by Knight Ridder / Tribune News Service (*Chapel Hill Herald*, June 28, 1998: 7):

> Q. *I heard that the Social Security retirement age is increasing. Is this true and if so, why?*
>
> A. Yes, it's true. When Social Security was just getting started back in 1935, the average American's life expectancy was just under age 60. Today it's more than 25 percent longer at just over 76. That means workers have more time for retirement, and more time to collect Social Security. And that's why Social Security's retirement age is gradually changing ... to keep pace with increases in longevity. A worker retiring today still needs to be age 65 to collect full benefits, but by 2027, workers will have to be age 67 for full retirement benefits.

Life expectancy and the current life table

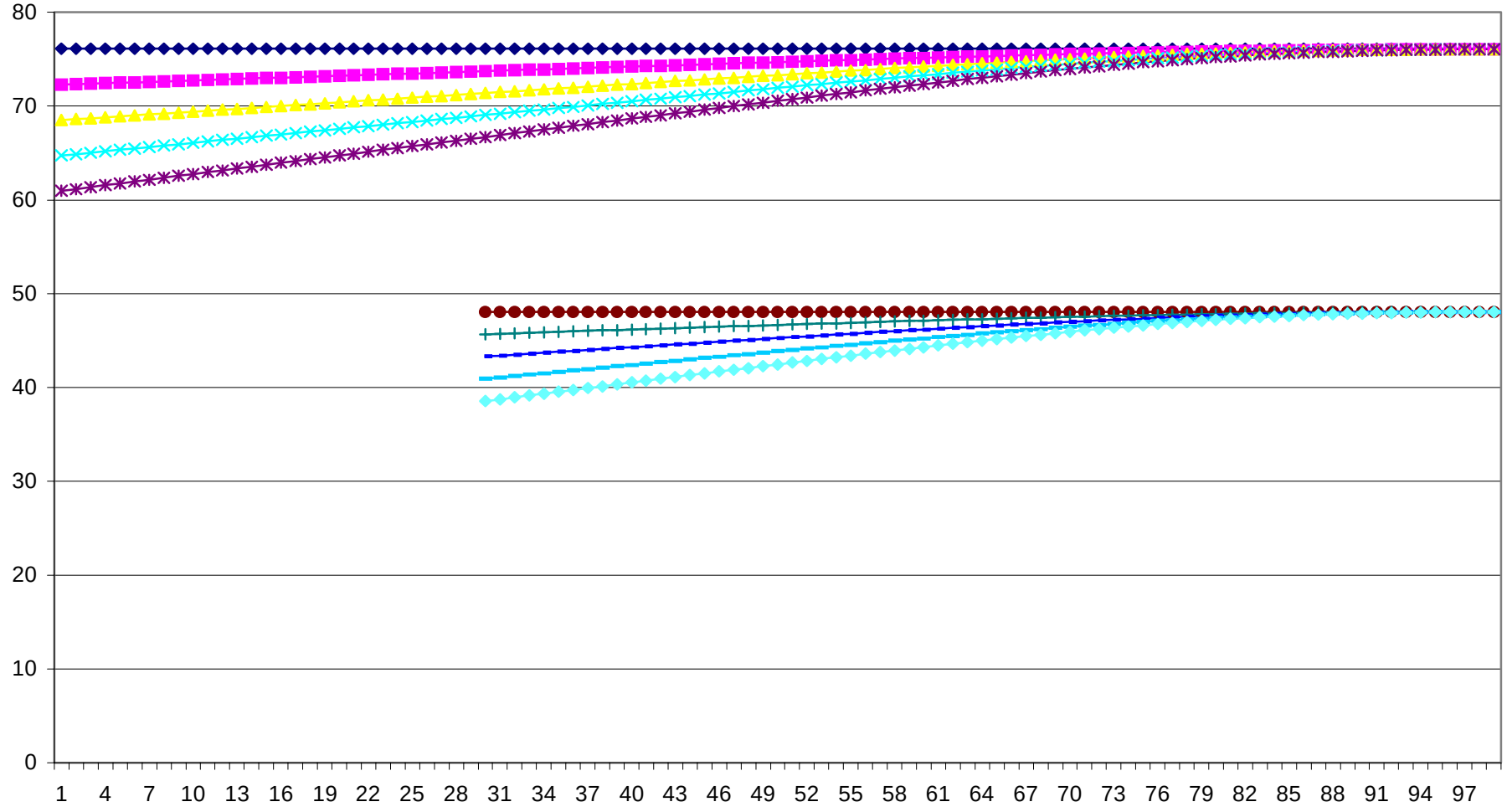
Excerpt from the U.S. 1993 abridged life table (total population)

Age interval (years)	Risk of death	Number still alive	Deaths
x - x+n	${}_nQ_x$	l_x	${}_nD_x$
(A)	(B)	(C)	(D)
<= 1 yr	.00835	100,000	835
1-5	.00177	99,165	176
5-10	.00106	98,989	105
10-15	.00126	98,884	125
15-20	.00431	98,759	426
20-25	.00545	98,333	536
25-30	.00612	97,797	599
30-35	.00797	97,198	775
35-40	.01031	96,423	994
40-45	.01343	95,429	1,282
45-50	.01842	94,147	1,734
50-55	.02808	92,413	2,595
55-60	.04421	89,818	3,971
60-65	.06875	85,847	5,902
65-70	.10148	79,945	8,113
70-75	.14838	71,832	10,658
75-80	.21698	61,174	13,274
80-85	.32300	47,900	15,472
>= 85 yr	1.00000	32,428	32,428

(Source: National Center for Health Statistics)

Age Interval (years)	Risk of death	Number still alive	Deaths	Years lived	Years remaining	Life expectancy
x-x+n	${}_nQ_x$	l_x	${}_nD_x$	${}_nL_x$	T_x	
(A)	(B)	(C)	(D)	(E)	(F)	(G)
<= 1 yr	.00835	100,000	835	99,290	7,553,897	75.5
1-5	.00177	99,165	176	396,248	7,454,607	75.2
5-10	.00106	98,989	105	494,659	7,058,359	71.3
10-15	.00126	98,884	125	494,177	6,563,700	66.4
15-20	.00431	98,759	426	492,829	6,069,523	61.5
20-25	.00545	98,333	536	490,352	5,576,694	56.7
25-30	.00612	97,797	599	487,486	5,086,342	52.0
30-35	.00797	97,198	775	484,098	4,598,856	47.3
35-40	.01031	96,423	994	479,771	4,114,758	42.7
40-45	.01343	95,429	1,282	474,168	3,634,987	38.1
45-50	.01842	94,147	1,734	466,717	3,160,819	33.6
50-55	.02808	92,413	2,595	455,985	2,694,102	29.2
55-60	.04421	89,818	3,971	439,733	2,238,117	24.9
60-65	.06875	85,847	5,902	415,279	1,798,384	20.9
65-70	.10148	79,945	8,113	380,318	1,383,105	17.3
70-75	.14838	71,832	10,658	333,442	1,002,787	14.0
75-80	.21698	61,174	13,274	273,494	669,345	10.9
80-85	.32300	47,900	15,472	201,029	395,851	8.3
>= 85	1.00000	32,428	32,428	194,822	194,822	6.0

Effect on life expectancy at age 1 and age 30 from an increase in risk of death of 5%, 10%, 15%, or 20% at any year of age



Cohort life tables

- In contrast to a current life table, a cohort life table displays the mortality experience of a population as it has actually occurred.
- Cohort life tables are the basis for survivorship analysis, an important technique for analyzing the effects of exposures or interventions.

Cohort effects

Age-period-cohort analysis of mean serum cholesterol (mg/dL, hypothetical data)

60-69	200[A]	210[B]	235[C]	240[D]	<u>230</u>[E]
50-59	205[B]	230[C]	235[D]	<u>225</u>[E]	215[F]
40-49	240[C]	230[D]	<u>220</u>[E]	210[F]	200[G]
30-39	225[D]	<u>215</u>[E]	205[F]	195[G]	185[H]
20-29	<u>210</u>[E]	200[F]	190[G]	180[H]	170[I]
	1950-59	1960-69	1970-79	1980-89	1990-96

Birth cohorts:

A - 1890-1899	D - 1920-1929	G - 1950-1959
B - 1900-1909	E - 1930-1939 (underlined)	H - 1960-1969
C - 1910-1919	F - 1940-1949	I - 1970-1979