INTRODUCTION

Age-specific survivorship data for populations of organisms may be summarized in the form of a life table. In its usual form, a life table shows for each age or interval the actual number of deaths, mortality rate, numbers of survivors, and future life expectancy for members of a group of individuals beginning life together (a cohort).

Life tables furnish a quantitative basis for the analysis and comparison of ecological factors affecting the survival and life expectancy of individuals in a population. Because of this, they are used extensively by insurance companies too! In addition, some life tables incorporate reproduction, and can be used to estimate the growth rate of the population.

We can gather mortality data and create a “life table”:

<table>
<thead>
<tr>
<th>Age</th>
<th>Proportion surviving to that age</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.0</td>
</tr>
<tr>
<td>1</td>
<td>0.99</td>
</tr>
<tr>
<td>2</td>
<td>0.95</td>
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<tr>
<td>3</td>
<td>0.90</td>
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<tr>
<td>…</td>
<td>etc. (this is the simplest form of a life table)</td>
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</tbody>
</table>

Much of the information in a life table can be shown graphically in the form of a survivorship curve. Such curves display for various ages, the number or the proportion of survivors from the original group. For numerous species studied, the curves usually fit one of three general shapes (Figure 1). Human survivorship typically fits a “Type 1” curve. Birds sometimes follow a “Type 2” curve. Fish, insects, and plants usually have survivorship curves resembling a “Type 3” curve.

Especially interesting though is that slight, but distinct differences can be seen when curves form separate communities are compared, or when cohorts from different decades for a single community are compared as you will do in this lab.

One method of obtaining life table data uses the age at death of individuals. Unfortunately, the discovery and sampling of dead plants or animals is limited by actions of decomposers that disintegrate dead organisms. Additional problems when sampling dead organisms include the fact that smaller individuals often decompose more rapidly than larger individuals, and that it is often difficult to determine the actual age of death. For these reasons, life-table data for wild populations are not always based on age except for organisms leaving growth rings (e.g. bivalves, fish, trees) or for which other information gives an accurate estimate of age (e.g. dentation, strong relationship between size and age).

We will cut through all the above problems by gathering life table data for a domestic species, Homo sapiens. This species is known to bury its dead in semi-permanent graveyards and leave at this gravesite evidence of age and death. Based on this evidence we will construct life tables, plot survivorship curves, and compute life table statistics.
PROCEDURE

We will visit graveyards close to campus with the goal of obtaining a fairly large data set in a short period of time.

1. Work in pairs. One person can read the data from a grave and the other record it. Try to visit as many gravestones as possible over the time allotted. We will attempt to cover as much of the graveyard as possible as a group, without counting any graves more than once.
2. For each individual in the graveyard (sometimes several are recorded on a single stone) record Sex (M, F, ?), Age at death (date of death minus date of birth) and Year of birth. Data from the entire class will be pooled when we return to lab.

When we return, summarize and pool your data in the following forms:

3. For each sex, tally the number of people living in the year 1870 who were (in that year) from 0-9 years old, 10-19 years old, 20-29, 30-39, etc. and record on the common data sheet that your Teaching Fellow will provide. Use only those who were alive in 1870. This may take some figuring.
4. For each sex, tally the number of people born in each decade (1820-1829, 1830-1839, etc.) who lived to be 0-9 years old, 10-19, 20-29, etc. Record this on your own tally sheet. Enter the data in the computer when you return or during the next class period.

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Practice:

In class, we are going to practice constructing life tables using different data collected elsewhere.

- For the first practice life table, we will assume that all of the organisms we have data for represent one cohort. In practice, data is often collected in a “static” way. Instead of “dynamically” following a group of individuals all born at the same time, we survey a population that were born over a long period of time, but died during the short period of our study, lumping them into a single cohort. This is often done in ecology because it is easier to collect sufficient data by using every dead creature we can find, rather than just those born together in time.
- For the second life table, we will use a data set that incorporates knowledge about the fecundity of females. This is an “all female” data set. We will try to determine the survivorship of females, the average number of female offspring that each adult female produces, the average lifespan of a female and the growth rate of the population.
First Practice Life Table (see Data 1)

1. We went out and counted the number of humans that died before they reached 10 years old, the number that reached 10 but not 20 years old, 20-29, 30-39, etc.
2. The **number of deaths in an age class** is commonly abbreviated as “$d_x$”. When you reach the bottom of the column, determine the total number of deaths – this equals the total number of tombstones we counted.
   - Put this number in the first row of the $l_x$ column. Here we are going to use $l_x$ as simply the **number of individuals surviving at the beginning of the age class**.
   - Fill in the $l_x$ column by subtracting $d_x$ from $l_x$ of the previous time period.
3. Calculate the life expectancy $e_x$ for each age class.

How do you do this? This calculation assumes that mortality is spread out evenly within each age interval. The **number of individuals living during each age interval** $L_x$ is thus the average of the number that enter that age interval and the number that live all the way through it.

$$L_x = (l_x + l_{x+1}) / 2$$

To calculate expectation of life, or how much longer an individual of age $x$ can expect to live, we must calculate an intermediate sum called total units of survival, $T_x$. $T_x$ is equal to the **sum of the $L_x$ values for age classes older than and including** the one for which the life-expectancy calculation is being made. Thus,

$$T_x = \sum L_i \text{ for age intervals } i \text{ to } x$$

Then, the expectation of life is the total age units of survival divided by the survivorship value.

$$E_x = T_x / l_x \text{ (for that age class)}$$

Remember that our expectation of life units is measured in ten-year chunks, thus, an $e_x$ of 3.2 units means that an individual can expect to live for another 32 years.

**There – we’ve completed our first Life Table!**
Practice Life Table #2 (See Data 2)

Here we are going to focus on something different – the reproduction of each age class. We will calculate $l_x$ as before, but this time, for convenience, we will represent this as a proportion of the cohort that lived to begin each age class. Using some data provided by your Teaching Fellow, fill in a life table and compute 3 variables:

$$R_0 = \sum l_x m_x$$

where $m_x$ is the average fecundity per female that is living in each age class, where fecundity is defined as # of female offspring.

$R_0$ is the net reproductive rate which is equal to the average number of female offspring left by a female in this cohort over her lifetime.

$$G = \frac{\sum (l_x m_x x)}{R_0}$$

$G$ is the average generation time for this cohort.

$$r = \frac{\ln (R_0)}{G}$$

$r$ is the intrinsic growth rate of the population (more on this in lecture)

<table>
<thead>
<tr>
<th>$x$ (age class)</th>
<th>$l_x$</th>
<th>$m_x$</th>
<th>$l_x m_x$</th>
<th>$l_x m_x x$</th>
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$R_0 =$
| Age (x) | 1 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 31 | 34 | 37 | 40 | 43 | 46 | 49 | 52 | 55 | 58 | 61 | 64 | 67 | 70 | 73 | 76 | 79 | 82 | 85 | 88 | 91 | 94 | 97 | 100 |
|---------|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
|        | 0 | 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 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| Sample data for Table 2 |

Demography Practice Data
Cemetery Worksheet

1a) Calculate a survivorship (I_x) curve for both males and females from any one decade. Plot both curves on the graph below. Label your graph! (axes, lines, and what decade you chose)

1b) Briefly describe the curves in words (how they change over time, how they compare to each other). Pick one interesting aspect of the graph and speculate about what may have caused it.
2a) Compare survivorship for one group (males or females) in two different decades. You could, for example, compare males in 1810-1819 to males in 1820-1829 (but you’re much more likely to see interesting differences if you pick decades separated by a longer stretch of time). Calculate and plot the curves below. Label your graph!

2b) Briefly describe the curves and then speculate about one aspect of the graph.
3a) Construct an age structure pyramid for the males and females that were alive in 1870 (‘Living in 1870’ data set). First, you must calculate the proportion in each age class that were alive, then plot the data below. (Again, add any necessary labels.)

3b) Briefly describe the age structure of one group (males or females), then point out any differences between that group and the other. For one difference, speculate about what might have caused it.