1. a. $P_1 = 54,000$, $P_2 = 58,320$, $P_3 = 62,986$. Doubling time $n = 9.01$ hr.

b. $P_1 = 265,000$, $P_2 = 280,900$, $P_3 = 297,754$. Doubling time $n = 11.9$ hr.

2. a. $r = 0.154$ and 1,312 million

b. Time for China's population to double is 48.3 years.

3. a. Growth constant $r = 0.09692$. The general solution is given by $P_n = 227(1.09692)^n$, where n is in decades after 1980. Populations in 2000 and 2020 are 273.1 and 328.6 million, respectively.

b. Growth constant $r = 0.2319$. Populations in 2000 and 2020 are 104.7 and 158.9 million, respectively. Mexico's population would double in 3.32 decades or 33.2 years.

c. The population of Mexico will first exceed that of U. S. in 103 years with Mexico having a population of 591.2 million and U. S. having a population of 588.6 million.

4. a. Growth constant $r = 0.2530$. The general solution is given by $P_n = 50.2(1.2530)^n$, where n is in decades after 1880.

b. Model predicts a population of 78.8 million, which has an error of 3.7% from the actual census data.

c. According to this model, the population doubles in 30.7 years.

5. Below is a table of the Malthusian growth model for the U. S. after 1900.

Year	Population	Model	Error
1900	75,994,575	75,994,575	0.00
1910	91,972,266	87,393,761	4.98
1920	105,710,620	100,502,825	4.93
1930	122,775,046	115,578,249	5.86
1940	131,669,275	132,914,987	0.95
1950	151,325,798	152,852,235	1.01
1960	179,323,175	175,780,070	1.98
1970	203,302,031	202,147,080	0.57
1980	226,545,805	232,469,142	2.61
1990	248,709,873	267,339,514	7.49

This model predicts the population to double in 49.6 years.

6. a. The solution is given by $P_n = 5000(1.015)^n$. The population doubles in 46.6 min.

b. The solution is given by $P_n = 1000(1.01748)^n$. The two populations are equal in 659.6 min with the populations at 92021937 bacteria.

7. Assuming initial investment of \$10,000 with an interest of 6%, we have the following results for investments after 2 and 5 years. Let n be the number of times interest is compounded in the year.

n	2 Years	5 Years
1	\$11,236.00	\$13,382.26
2	\$11,255.09	\$13,439.16
4	\$11,264.93	\$13,468.55
12	\$11,271.60	\$13,488.50

8. a. The populations are $b_1 = 1,050,000$, $b_2 = 1,102,500$, $b_3 = 1,1157,625$ with general solution given by $b_n = 1,000,000 \times (1.05)^n$.

b. Doubling time is $n = 7.27$ for the second population.

c. The two populations are equal when $n = 34.6$.

9. a. The populations are $y_1 = 2100$, $y_2 = 2205$, $y_3 = 2315$ with the general solution given by $y_n = 2000 \times (1.05)^n$.

b. The doubling time is $n = 10.24$ for this competing group of herbivores.

c. The populations are equal when $n = 73.47$.

10. a. The first investment is the better one. After one year the Municipal Bond gives \$10,825.00, while the Treasury Note gives \$10,824.32.

b. The Municipal Bond after 5 years is \$14,693.28.

11. a. The populations for the first 5 days are $P_1 = 43,200$, $P_2 = 46,224$, $P_3 = 48,997$, $P_4 = 51,447$, $P_5 = 53,505$.

b. Growth rate is zero at $t = 8$ days with $P_8 = 56,775$.

c. There are two ways to look at this solution. First, one iterates until the population drops below one individual in which case the answer is either $t = 52$ days (below 1) or $t = 53$ days (below 0.5). Second, determine when the factor $1 + k(t_n) = 0$, which occurs at $t = 108$ days. The first represents numerical extinction, while the second represents a theoretical upper bound for the extinction.

12. a. The Malthusian growth model estimates Italy's populations in 1990 and 2000 as 60.0 and 63.6 million people. The doubling time for this model would be 117 years.

b. The Nonautonomous Malthusian growth model predicts Italy's populations in 1990 and 2000 as 58.4 and 59.4 million people. The growth term $k(t_n)$ drops to zero near 1999, so the population would level off then.

c. Both predicted values are high with the errors being 2.9data are clearly leveling off now, which is consistent with the predicted leveling off in 1999.