# Biotechnology (26.1201) T-Chart

**Calculate Change in Measurements = Construct and compare linear, quadratic and exponential models to solve problems**

**Program Task: POS:** 300: Demonstrate Laboratory Knowledge And Skills

**POS Task:** 303 Perform basic laboratory math skills

**Program Associated Vocabulary:**
DECAY, GROWTH, HALF-LIFE, SHELF-LIFE

**Program Formulas and Procedures:**
In the Health Occupations field, as in the real world, things may double, but they also may decay. Numbers may change, for example: the amount of horsepower an engine produces, the number of germs growing in a bottle, the deprecation value of a car, or the amount which aspirin decreases in our body after a few hours.

**Formulas and Procedures**: Sometimes we have to use a mathematical process called a logarithm. The **logarithm** of a number is the **exponent** to which another fixed value, the **base**, must be raised to produce that number. For example, the logarithm of 1000 to base 10 is 3, because 1000 is 10 to the power 3: $1000 = 10 \times 10 \times 10 = 10^{3}$.

**Example:** Right after ingesting aspirin, 20,000 PPM of a particular additive that reduces pain enters the blood stream. If the additive breaks down 25% an hour, how long before it reaches 1250 PPM and can longer be considered an effective analgesic?

**IV=Initial Value; NV=New Value; r=Rate; $^{t}$ =Time**

$$IV \times (1 - r)^t = NV$$

*In this case we SUBTRACT*

*because the additive is decreasing*

$$20,000 \times (1 - .25)^t = 1250$$

$$20,000 \times (.75)^t = 1250$$

*Divide both sides by* 20,000

$$\frac{\log .0625}{\log 0.75} = 9.6\,hours$$

**PA Core Standard:** CC.2.2.HS.C.5

**Description:** Construct and compare linear, quadratic and exponential models to solve problems.

**PA Core Standard:** CC.2.2HS.D.9

**Description:** Use reasoning to solve equations and justify the solution method.

**Math Associated Vocabulary:**
EXPONENTIAL, RECIPROCAL, ABSOLUTE VALUE, RAISING TO A POWER, FINDING ROOTS, EXPONENTS, SCIENTIFIC NOTATION

**Program Formulas and Procedures:**
**Scientific Notation**:

A number in the form **$a \times 10^n$**, where
$a \geq 1$ and $a < 10$ and n is an integer.

Example: $2.3 \times 10^5$ Not an Example: $.23 \times 10^5$

**Formulas and Procedures:**
Expressing numbers in scientific notation from standard form:

1. Identify where the decimal point must be placed. Remember that the number a must have one single digit in front of the decimal.
2. Count the number of places the decimal point must move to get to the desired location (from 1). This is the exponent, n. *Note, if the original number has no decimal, then place the original decimal at the far right of the number. Ex. 100 would become 100.
3. If the decimal place must move left, the exponent must be positive. If the decimal place must move right, the exponent is negative.
4. Write the number in scientific notation.

**Example 1**: Write 2,400,000 in scientific notation.

1. The decimal must go between the 2 and 4. 2.400000, so a = 2.4
2. The original decimal 2,400,000. had to move 6 places to the left, so n = 6
3. The decimal moved left so n = 6
   The answer is $2.4 \times 10^6$ or 2.4E+06

**Example 2**: Write 0.00435 in scientific notation.

1. The decimal must go between the 4 and 3, so a = 4.35
2. The original decimal had to move 3 places so n = 3.
3. Since the decimal moved 3 places to the right, n = -3
   The answer is $4.35 \times 10^{-3}$ or 4.35E-03

**Teacher's Script - Comparing and Contrasting**

The growth rate ($r$) is the fractional amount added or removed within a given time period.

- If the amount is increasing, $\boldsymbol{r}$ will be positive; if decreasing, $\boldsymbol{r}$ will be negative
- Many times, the growth rate is given as a percentage and must be converted to a decimal first. (70% = 70÷100 = 0.70)
- For half-life problems, use a growth rate of -50% or -0.50 ($1+r$ = 1 - 0.50 = 0.50)
- For doubling problems, use a growth rate of 100% or +1.00 ($1+r$ = 1 + 1 = 2)

The growth period ($\boldsymbol{n}$) is calculated by dividing the elapsed time by the time indicated in the growth rate.

**Example**: If 100 bacteria double every 30 minutes, how many would you have in 135 minutes?

$\boldsymbol{r}$ = +100% per 30 minutes, so $\boldsymbol{n} = \frac{135\,\text{min}}{30\,\text{min}} = 4.5$ growth periods (bacteria will increase 100% 4.5 times)

For half-life problems, the growth rate time is the half-life, so $n = \frac{t}{t_{half}}$.

The exponential growth and decay formulas can be used in many different types of applications (finance, biological, radioactivity …), but technical trades will often encounter them in problems about material or substance growth and decay. Since growth or decay of these materials is continuous, the continuous growth formula should be used when accuracy of the result is very important.

$\boldsymbol{e}$, aka Euler's constant, is an irrational number, like $\pi$, that can be found on most scientific calculators.

Calculating $\boldsymbol{k}$ (the growth constant): When using the continuous growth formula, $\boldsymbol{k}$ must be calculated from the information given. To do so, the natural logarithm function ($ln$) is used (a calculator function):

$$k = \frac{\ln(1+r)}{t}$$

**Example**: The half-life of radium is 1800 years (50% loss in 1800 years)

$r$ = -0.50, $t$ = 1800, $k = \frac{\ln(1-0.50)}{1800} = \frac{\ln(0.50)}{1800}$ = -0.000385

**Common Mistakes Made By Students**

- Not performing the order of operations correctly: Parentheses ($1+r$), Exponent ($^{\boldsymbol{n}}$), Multiplication ($A_o$)
- Setting $\boldsymbol{r}$ to the amount of material remaining after a change instead of the growth or decay change ("$1+r$" is the amount remaining after growth)
- Setting the sign of r incorrectly ("$1+r$" should be greater than 1.0 if growing and less than 1.0 if decaying)

**Lab Teacher's Extended Discussion**

Technical tasks are usually not presented using this model. Therefore, it is important for technical instructors to demonstrate to students how these math concepts link to and are relevant in their technical training, and that technical teachers present the math concepts in a way which shows a relationship to the math which CTE students use in their academic school settings.

To become that well-rounded teacher, do the math, make it your business to reach the comfort level necessary for teaching the math concepts and formulas that make Health Occupations the profitable and satisfying career that we all know it can be.

# Biotechnology (26.1201) T-Chart

| Problems | Occupational (Contextual) Math Concepts Solutions |
|---|---|
| 1. A particular reagent in solution contains 75% its original formulation. The solution has a half-life of 10 years. How old is the reagent in solution? Half-life formula: $NV = (\frac{1}{2})^{T/half}$ | |
| 2. 800,000 bacteria growing on a culture dish. After administering antibiotics the bacteria are disappearing at a rate of 12% a day. There were still 135,500 bacteria remaining. How many days before there are only 10,000 bacteria remaining and the infection considered cured? | |
| 3. A new drug supplement promises to increase a particular hormone by 5% a month, which should hopefully eliminate a patients symptoms. Currently the level is 140ppm, but the body requires 400 ppm. How long will it take to meet required levels of the chemical? | |

| Problems | Related, Generic Math Concepts Solutions |
|---|---|
| 4. A particular brand of anti-freeze contains 75% its original Ethylene Glycol (EC). Ethylene Glycol has a half-life of 10 years. How old is the anti-freeze? Half-life formula: $NV = (\frac{1}{2})^{T/half}$ | |
| 5. In 1957, Chevrolet built 320,000 Belair cars. These classics are now disappearing at a rate of 20% a year. In 2007 there were still 12,500 of these vehicles driving around. How many years before there are only 100 left on the road? | |
| 6. A city currently has a population of 15,600. The number of people living in the city doubles every 10 years. How many people will be living in the city in 18 years, 24 years and 35 years? | |

| Problems | PA Core Math Look Solutions |
|---|---|
| 7. $14^x = 86$ solve for $x$ | |
| 8. $\log 2x = 4$ solve for $x$ | |
| 9. $\log(2x) = 2$ solve for $x$ | |

| Problems | Occupational (Contextual) Math Concepts Solutions |
|---|---|
| 1. A particular reagent in solution contains 75% its original formulation. The solution has a half-life of 10 years. How old is the reagent in solution? Half-life formula: $NV = (\frac{1}{2})^{T/half}$ | $= \log .5^{T/10} = .75 \quad =^{T/10} \log .5 = \log .75$ <br> Multiple both sides by 10 to cancel $^{T/10}$ <br> $\frac{10 \log .75}{\log .50} = 4.15 years$ |
| 2. 800,000 bacteria growing on a culture dish. After administering antibiotics the bacteria are disappearing at a rate of 12% a day. There were still 135,500 bacteria remaining. How many days before there are only 10,000 bacteria remaining and the infection considered cured? | $Q = Q_0(1-r)^t \quad = 800,000(1-.12)^t = 10,000 \quad = 800,000(.88)^t = 10,000$ <br> Divide both sides by 800,000 <br> $= \frac{\log .0125}{\log .88} = 37.3$ days |
| 3. A new drug supplement promises to increase a particular hormone by 5% a month, which should hopefully eliminate a patient's symptoms. Currently the level is 140ppm, but the body requires 400 ppm. How long will it take to meet required levels of the chemical? | $IV \times (1+r)^t = NV \quad IV \times (1.05)^t = 400 ppm$ <br> $140 ppm \times 1.05^t = 400 ppm$ <br> *Divide both sides by* 140 <br> $\frac{147}{140} \; \frac{400}{140} = \frac{\log 2.86}{\log 1.05} = 21.5 months$ |
| **Problems** | **Related, Generic Math Concepts Solutions** |
| 4. A particular brand of anti-freeze contains 75% its original Ethylene Glycol (EC). Ethylene Glycol has a half-life of 10 years. How old is the anti-freeze? Half-life formula: $NV = (\frac{1}{2})^{T/half}$ | $= \log .5^{T/10} \quad = .75 \quad =^{T/10} \log .5 \quad = \log .75$ <br> Multiple both sides by 10 to cancel $^{T/10}$ <br> $\frac{10 \log .75}{\log .50} = 4.15 years$ |
| 5. In 1957, Chevrolet built 320,000 Belair cars. These classics are now disappearing at a rate of 20% a year. In 2007 there were still 12,500 of these vehicles driving around. How many years before there are only 100 left on the road? | $Q = Q_0(1-r)^t \quad = 12,500(1-.20)^t = 100 \quad = 12,500(.80)^t = 100$ <br> Divide both sides by 12,500 <br> $= \frac{\log .008}{\log .80} = 21.64 years$ |
| 6. A city currently has a population of 15,600. The number of people living in the city doubles every 10 years. How many people will be living in the city in 18 years? 24 years? and 35 years? | $NV = IV(2)^{(18/10)} \quad NV = 54,322$ <br> $NV = IV(2)^{(24/10)} \quad NV = 82,337$ <br> $NV = IV(2)^{(35/10)} \quad NV = 176,493$ |
| **Problems** | **PA Core Math Look Solutions** |
| 7. $14^x = 86$ solve for $x$ | $\frac{\log 86}{\log 14} = 1.688 \quad x = 1.688$ Check your work: $14^{1.688} = 86.032$ |
| 8. $\log 2x = 4$ solve for $x$ | $\log 2x = 4, 2x = 10^4, 2x = 10,000$ <br> $x = \frac{2x}{2} \frac{10,000}{2} \; x = 5000$ Check your work: $\log 2 \times 5000 = 4$ |
| 9. $\log(2x) = 2$ solve for $x$ | $\log(2x) = 2, \; 2x = 10^2, \; 2x = 100, \div both\ sides\ by\ 2, \quad x = 50$ <br> Check your work: $\log(2 \times 50) = 2$ |