***Welcome to* SCN334 *Advanced Placement Environmental Science* (APES)**

The AP Environmental Science course is equivalent to a one-semester, Introductory Environmental Science college-level course. Students participate in APES by employing the scientific principles, concepts, and methodologies required to understand interrelationships in the natural world. Environmental Science is an interdisciplinary science, which embraces topics from Earth Science, Biology, Physics, Economics, Math, Government Studies, Chemistry, and Geography. Students identify and analyze natural and human-made environmental problems, evaluate the relative risks associated with these problems, and examine alternative solutions for resolving or preventing them.

Those who are able to earn a qualifying score on an APES Exam, are typically eligible to receive college credit and/or placement into more advanced environmental courses in college. Equally as important, if students understand and apply what they learn in APES, they will have the ability to make decisions throughout their lives that will enhance local and global sustainability.

Summer Assignments:

I*t is important that students complete the following activities to build a basic foundation for the understanding and application of APES concepts.*

- ***Math Review*** – Complete *Practice* without a calculator as instructed. Provide details, explanations, and proof in the form of calculations with units of measurement.
- ***Scholarly Reading Assignment*** - The article focuses on anthropogenic changes to the environment. Anthropogenic is a term used frequently in APES.
- ***Chapter One***
- ***Spend Free Time Observing Nature*** - Look around for the relationships that exist in the natural world, and realize that you too are part of nature.

Please contact me at mderenzis@pthsd.net if necessary, and join our APES Google Classroom, class code z50k0y.

Part I: AP Environmental Science Math Skills Review

The first assignment is to help you freshen up your math skills. This review is important for you to be comfortable with APES math. In APES all calculations must be completed without a calculator in order to prepare for the AP Environmental Science exam. Most calculations on the tests and exams are relatively easy calculations with results in the form of whole numbers or only a few decimal places. The challenge is in setting up the problems correctly and knowing enough basic math to solve the problems. If this news makes you very nervous, please DO NOT STRESS. With practice, you will be a math expert by the time the exam rolls around. So, DO NOT USE A CALCULATOR while completing this review activity.

Contents

Important Reminders

1. **Write out all of your work, even if it's something really simple.** This is required on the APES exam so it will be required on all your assignments, labs, quizzes, and tests as well.
2. Include **UNITS** in each step. Your answers always need units and it's easier to keep track of them if you write them in every step.
3. Check your work. Go back through each step to make sure you didn't make any mistakes in your calculations. Also check to see if your answer makes sense. For example, a person probably will not eat 13 million pounds of meat in a year. If you get an answer that seems unlikely, it probably is. Go back and check your work.

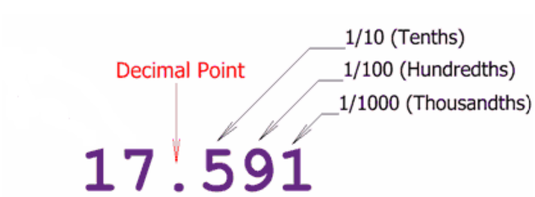
Directions

Read each section below for review. Look over the examples and use them for help on the practice problems. **When you reach the *Practice* section, record all work on a separate sheet of paper. Be sure to include units of measurement throughout the solution**.

Decimals

Part I: The Basics

Decimals are used to show fractional numbers. The first number behind the decimal is the tenths place, the next is the hundredths place, the next is the thousandths place. Anything beyond that should be changed into scientific notation (which is addressed in another section.)



Part II: Adding or Subtracting Decimals

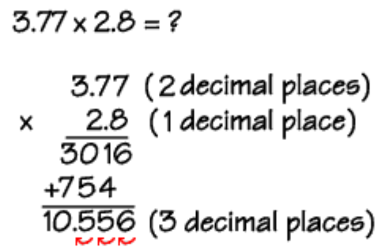
To add or subtract decimals, make sure you line up the decimals and then fill in any extra spots with zeros. Add or subtract just like usual. Be sure to put a decimal in the answer that is lined up with the ones in the problem.

```
 123.0000
   0.0079
 +43.5000
 --------
 166.5079
```

```
  27.583
 - 0.200
 -------
  27.383
```

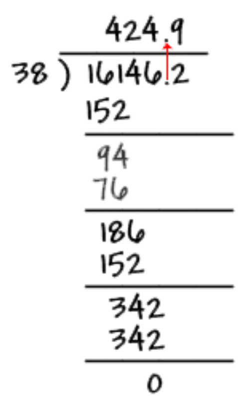
Part III: Multiplying Decimals

Line up the numbers just as you would if there were no decimals. DO NOT line up the decimals. Write the decimals in the numbers but then ignore them while you are solving the multiplication problem just as you would if there were no decimals at all. After you have your answer, count up all the numbers behind the decimal point(s). Count the same number of places over in your answer and write in the decimal.

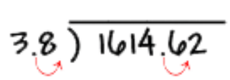


Part IV: Dividing Decimals

Scenario One: If the **divisor** (the number after the / or before the ⟌) does not have a decimal, set up the problems just like a regular division problem. Solve the problem just like a regular division problem. When you have your answer, put a decimal in the same place as the decimal in the **dividend** (the number before the / or under the ⟌).



Scenario Two: If the divisor does have a decimal, make it a whole number before you start. Move the decimal to the end of the number, then move the decimal in the dividend the same number of places.



Then solve the problem just like a regular division problem. Put the decimal above the decimal in the dividend. (See Scenario One problem).

Practice: Remember to show all your work, include units if given, and NO CALCULATORS! All work and answers must be submitted on a separate answer sheet.

1. 1.678 + 2.456 =
2. 344.598 + 276.9 =
3. 1229.078 + 0.0567 =
4. 45.937 – 13.43 =
5. 199.007 – 124.553 =
6. 90.3 – 32.679 =
7. 28.4 x 9.78 =
8. 24.45 x 98.4 =
9. 1256.93 x 12.38 =
10. 64.5 / 5 =
11. 114.54 / 34.5 =
12. 3300.584 / 34.67 =

Averages

To find an average, add all the quantities given and divide the total by the number of quantities.

Example: Find the average of 10, 20, 35, 45, and 105.

Step 1: Add all the quantities. 10 + 20 + 35 + 45 + 105 = 215
Step 2: Divide the total by the number of given quantities. 215 / 5 = 43

Practice: Remember to show all your work, include units if given, and NO CALCULATORS! All work and answers must be submitted on a separate answer sheet.

13. Find the average of the following numbers: 11, 12, 13, 14, 15, 23, and 29
14. Find the average of the following numbers: 124, 456, 788, and 343
15. Find the average of the following numbers: 4.56, 0.0078, 23.45, and 0.9872

Percentages Introduction:

Percents show fractions or decimals with a denominator of 100. Always move the decimal TWO places to the **right** to convert a decimal into a percentage or TWO places to the **left** to convert a percent into a decimal.

Examples: 0.85 = 85%. 0.008 = 0.8%

Part I: Finding the Percent of a Given Number

To find the percent of a given number, change the percent to a decimal and MULTIPLY.

Example: 30% of 400

Step 1: 30% = 0.30
Step 2: 400
x 0.30
12000

Step 3: Count the digits behind the decimal in the problem and add decimal to the answer.
12000 → 120.00 → 120

Part II: Finding the Percentage of a Number

To find what percentage one number is of another, divide the first number by the second, then convert the decimal answer to a percentage.

Example: What percentage is 12 of 25?

Step 1: 12/25 = 0.48
Step 2: 0.48 = 48% (12 is 48% of 25)

Part III: Finding Percentage Increase or Decrease

To find a percentage increase or decrease, first find the percent change, then add the change to, or subtract the change from, the original number.

Example: Kindles have dropped in price 18% from $139.
What is the new price of a Kindle?

Step 1: $139 x 0.18 = $25
Step 2: $139 - $25 = $114

<u>Part IV: Finding a Total Value</u>

To find a total value, given a percentage of the value, DIVIDE the given number by the given percentage.

Example: If taxes on a new car are 8% and the taxes add up to $1600, what is the cost of the new car?

Step 1: 8% = 0.08
Step 2: $1600 / 0.08 = $160,000 / 8 = $20,000

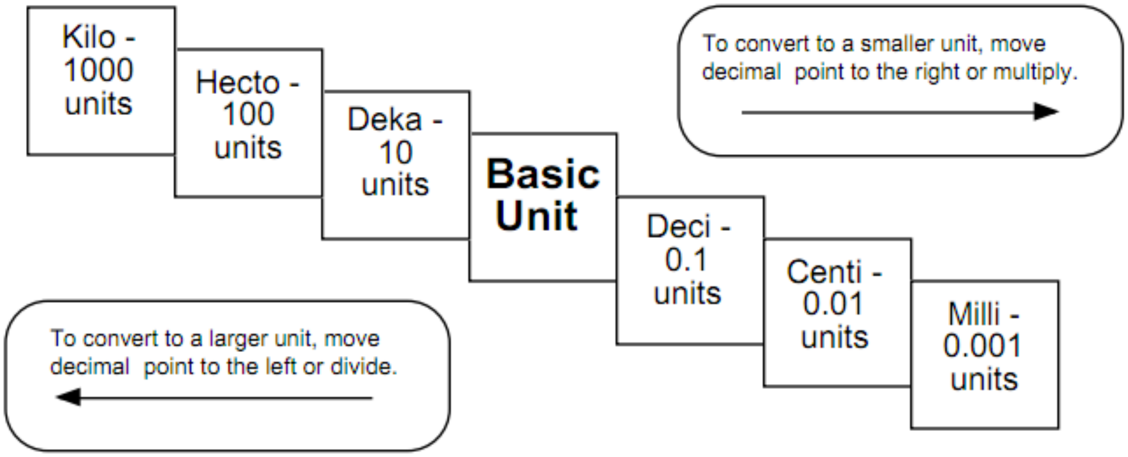
(Remember when the divisor has a decimal, move it to the end to make it a whole number and move the decimal in the dividend the same number of places. 0.08 becomes 8, 1600 becomes 160000.)

Practice: Remember to show all your work, include units if given, and NO CALCULATORS! All work and answers must be submitted on a separate answer sheet.

16. What is 45% of 900?
17. Thirteen percent of a 12,000 acre forest is being logged. How many acres will be logged?
18. A water heater tank holds 280 gallons. Two percent of the water is lost as steam. How many gallons remain to be used?
19. What percentage is 25 of 162.5?
20. What percentage is 35 of 2800?
21. 14,000 acres of a 40,000 acre forest burned in a forest fire. What percentage of the forest was damaged?
22. You have driven the first 150 miles of a 2000 mile trip. What percentage of the trip have you traveled?
23. Home prices have dropped 5% in the past three years. An average home in Indianapolis three years ago was $130,000. What's the average home price now?
24. The Greenland Ice Sheet contains 2,850,000 cubic kilometers of ice. It is melting at a rate of 0.006% per year. How many cubic kilometers are lost each year?
25. 235 acres, or 15%, of a forest is being logged. How large is the forest?
26. A teenager consumes 20% of her calories each day in the form of protein. If she is getting 700 calories a day from protein, how many calories is she consuming per day?
27. In a small oak tree, the biomass of insects makes up 3000 kilograms. This is 4% of the total biomass of the tree. What is the total biomass of the tree?

<u>Metric Units</u>

Kilo-, centi-, and milli- are the most frequently used prefixes of the metric system. You need to be able to go from one to another without a calculator. You can remember the order of the prefixes by using the following sentence: *King Henry Died By Drinking Chocolate Milk*. Since the multiples and divisions of the base units are all factors of ten, you just need to move the decimal to convert from one to another.



Example: 55 centimeters = ? kilometers

Step 1: Determine how many places to move the decimal. King Henry Died By Drinking… is five places. (Count the one you are going to, but not the one you are on.)

*Step 2: Move the decimal five places to the **left** when converting **from smaller to larger**. Do not forget to add a zero placeholder to the left of the decimal point.*

55 centimeters = 0.00055 kilometers

Example: *19.5 kilograms = ? milligrams*

Step 1: Figure out how many places to move the decimal. … Henry Died By Drinking Chocolate Milk is six places. (Count the one you are going to, but not the one you are on.)

*Step 2: Move the decimal six places to the **right** when converting **from larger to smaller**. In this case you need to add zeros to the right.*

19.5 kilograms = 19,500,000 milligrams

Practice: Remember to show all your work, include units if given, and NO CALCULATORS! All work and answers must be submitted on a separate answer sheet.

28. 1200 kilograms = ? milligrams
29. 14000 millimeters = ? meters
30. 670 hectometers = ? centimeters
31. 544 liters = ? milliliters
32. 0.078 kilometers = ? meters
33. 17 grams = ? kilograms

Scientific Notation

Introduction:

Scientific notation is a shorthand way to express large or tiny numbers. Since you will need to do calculations throughout the year WITHOUT A CALCULATOR, we will consider anything **over 1000** to be a large number. Writing these numbers in scientific notation will help you do your calculations much quicker and easier and will help prevent mistakes in conversions from one unit to another. Like the metric system, scientific notation is based on factors of 10. A large number written in scientific notation looks like this:

$$1.23 \times 10^{11}$$

The number before the x (1.23) is called the coefficient. The coefficient must be greater than 1 and less than 10. The number after the x is the base number and is always 10. The number in superscript (11) is the exponent.

Part I: Writing Numbers in Scientific Notation

To write a large number in scientific notation, put a decimal after the first digit. Count the number of digits after the decimal you just wrote in. This will be the exponent. Drop any zeros so that the coefficient contains as few digits as possible.

Example: 123,000,000,000

Step 1: Place a decimal after the first digit. 1.23000000000

Step 2: Count the digits after the decimal…there are 11.

Step 3: Drop the zeros and write in the exponent. 1.23×10^{11}

Writing tiny numbers in scientific notation is similar. The only difference is the decimal is moved to the left and the exponent is a negative. A tiny number written in scientific notation looks like this:

$$4.26 \times 10^{-8}$$

To write a tiny number in scientific notation, move the decimal after the first digit that is not a zero. Count the number of digits before the decimal you just wrote in. This will be the exponent as a negative. Drop any zeros before or after the decimal.

Example: 0.0000000426

Step 1: 00000004.26

Step 2: Count the digits before the decimal…there are 8.

Step 3: Drop the zeros and write in the exponent as a negative. 4.26×10^{-8}

Part II: Adding and Subtracting Numbers in Scientific Notation

To add or subtract two numbers with exponents, the **exponents must be the same**. You can do this by moving the decimal one way or another to get the exponents the same. Once the exponents are the same, add (if it's an addition problem) or subtract (if it's a subtraction problem) the coefficients just as you would any regular addition problem (review the previous section about decimals if you need to). The exponent will stay the same. Make sure your answer has only one digit before the decimal – you may need to change the exponent of the answer.

Example: $1.35 \times 10^{6} + 3.72 \times 10^{5} = ?$

Step 1: Make both exponents the same. It's easier to convert the larger exponent to avoid having to change the exponent in the answer. Convert the 5 exponent to 6 for this problem.

$$3.72 \times 10^{5} \rightarrow 0.372 \times 10^{6}$$

Step 2: Add the coefficients as you would regular decimals, remembering to line up the decimals.

$$\begin{array}{r} 1.35 \\ +\ 0.372 \\ \hline 1.722 \end{array}$$

Step 3: Write the answer including the exponent, which is the same as what you started with.

$$1.722 \text{ x } 10^6$$

Part III: Multiplying and Dividing Numbers in Scientific Notation

To multiply exponents, multiply the coefficients just as you would regular decimals. Then **add the exponents** to each other. The exponents DO NOT have to be the same.

Example: $1.35 \text{ x } 10^6$ X $3.72 \text{ x } 10^5 = ?$

Step 1: Multiply the coefficients.

$$\begin{array}{r} 1.35 \\ \text{x}\ \ 3.72 \\ \hline 270 \\ 9450 \\ 40500 \\ \hline 50220 \end{array} \rightarrow 5.022$$

Step 2: Add the exponents.

$$5 + 6 = 11$$

Step 3: Write your final answer.

$$5.022 \text{ x } 10^{11}$$

To divide exponents, divide the coefficients just as you would regular decimals, then **subtract the exponents**. In some cases, you may end up with a negative exponent.

Example: $5.635 \text{ x } 10^3$ / $2.45 \text{ x } 10^6 = ?$

Step 1: Divide the coefficients.

$$5.635 / 3.45 = 2.3$$

Step 2: Subtract the exponents.

$$3 – 6 = -3$$

Step 3: Write your final answer.

$$2.3 \text{ x } 10^{-3}$$

Practice: Remember to show all your work, include units if given, and NO CALCULATORS! All work and answers must be submitted on a separate answer sheet.

Write the following numbers in scientific notation:

34. 145,000,000,000
35. 13 million
36. 435 billion
37. 0.000348
38. 135 trillion
39. 24 thousand

Complete the following calculations:

40. $3 \times 10^3 + 4 \times 10^3$
41. $4.67 \times 10^4 + 323 \times 10^3$
42. $7.89 \times 10^{-6} + 2.35 \times 10^{-8}$
43. $9.85 \times 10^4 - 6.35 \times 10^4$
44. $2.9 \times 10^{11} - 3.7 \times 10^{13}$
45. $1.278 \times 10^{-13} - 1.021 \times 10^{-10}$
46. three hundred thousand plus forty-seven thousand
47. 13 million minus 11 thousand
48. $1.32 \times 10^8 \text{ X } 2.34 \times 10^4$
49. $3.78 \times 10^3 \text{ X } 2.9 \times 10^2$
50. three million times eighteen thousand
51. one thousandth of seven thousand
52. eight ten-thousandths of thirty-five million
53. $3.45 \times 10^9 \;/\; 2.6 \times 10^3$
54. $1.98 \times 10^{-4} \;/\; 1.72 \times 10^{-6}$
55. twelve thousand divided by four thousand

Dimensional Analysis

Introduction

Dimensional analysis is a way to convert a quantity given in one unit to an equal quantity of another unit by lining up all the known values and multiplying. It is also sometimes called factor-labeling. The best way to start a factor-labeling problem is by using what you already know. In some cases you may use more steps than a classmate to find the same answer, but it doesn't matter. Use what you know, even if the problem goes all the way across the page.

In a dimensional analysis problem, start with the given value and its unit of measurement and work toward the desired unit of measurement, by writing equal values side by side. Remember the goal is to cancel each of the intermediate units. To cancel a unit in the numerator (top part), you must have the same unit in the denominator (bottom). Likewise, to cancel a unit in the denominator, the same unit must be in the numerator. Once the problem is written, multiply across the top and bottom, and then divide the top by the bottom

Example: 3 years = ? seconds

Step 1: Start with the value and unit given. There may or may not be a number on the bottom.

$$\left[\frac{3\text{ years}}{}\right]$$

Step 2: Start by writing the known equivalents, in an order that will allow you to cancel units on the top and bottom. Because years are on top, place years on the bottom in the next equivalent. Continue to cancel units in the sequence until the unit needed (in this case seconds) on the top.

$$\left[\frac{3\text{ }\cancel{\text{years}}}{}\right]\left[\frac{365\text{ }\cancel{\text{days}}}{1\text{ }\cancel{\text{year}}}\right]\left[\frac{24\text{ }\cancel{\text{hours}}}{1\text{ }\cancel{\text{day}}}\right]\left[\frac{60\text{ }\cancel{\text{minutes}}}{1\text{ }\cancel{\text{hour}}}\right]\left[\frac{60\text{ seconds}}{1\text{ }\cancel{\text{minute}}}\right]$$

Step 3: Multiply all the values across the top. Convert the answer into scientific notation if it's a very large or small number. Include the units of measurement with the answer.

$$3 \times 365 \times 24 \times 60 \times 60 = 9.46 \times 10^{7} \text{ seconds}$$

Step 4: Multiply all the values across the bottom. Write the result in scientific notation if necessary. Include the units of measurement in the answer. In this case all units were cancelled.

$$1 \times 1 \times 1 \times 1 = 1$$

Step 5: Divide the top number by the bottom number. Remember to include units.

$$9.46 \times 10^{7} \text{ seconds}/1 = 9.46 \times 10^{7} \text{ seconds}$$

Step 6: Review the answer to check if it makes sense. 9.46×10^{7} is a very large number. Does it make sense that there are a lot of seconds in three years? YES! If the answer were a small number, you would need to re-check tour calculations for errors.

In many APES problems, units must be converted in this manner. Don't panic; convert the top unit first and then the bottom unit.

Example: 50 miles per hour = ? feet per second

Step 1: Begin with the value and units provided. In this example there are units on top and bottom which must be converted.

$$\left[\frac{50 \text{ miles}}{1 \text{ hour}}\right]$$

Step 2: Convert miles to feet first.

$$\left[\frac{50 \cancel{\text{miles}}}{1 \text{ hour}}\right] \left[\frac{5280 \text{ feet}}{1 \cancel{\text{mile}}}\right]$$

Step 3: Continue the problem by converting hours to seconds.

$$\left[\frac{50 \cancel{\text{miles}}}{1 \cancel{\text{hour}}}\right] \left[\frac{5280 \text{ feet}}{1 \cancel{\text{mile}}}\right] \left[\frac{1 \cancel{\text{hour}}}{60 \cancel{\text{minutes}}}\right] \left[\frac{1 \cancel{\text{minute}}}{60 \text{ second}}\right]$$

Step 4: Multiply across the top and bottom. Divide the top by the bottom. Include units of measurement in each step. Use scientific notation for very large or small numbers.

$$50 \times 5280 \text{ feet} \times 1 \times 1 = 264000 \text{ feet}$$
$$1 \times 1 \times 60 \times 60 \text{ seconds} = 3600 \text{ seconds}$$
$$264000 \text{ feet} / 3600 \text{ seconds} = 73.33 \text{ feet/second}$$

Practice: Remember to show all your work, include units if given, and NO CALCULATORS!
All work and answers must be submitted on a separate answer sheet.
Use scientific notation when appropriate.

Conversions:

1 square mile = 640 acres
1 hectare (Ha) = 2.47acres
1 kw-hr = 3,413 BTUs
1 barrel of oil = 159 liters
1 metric ton = 1000 kg

56. 134 miles = ? inches
57. 8.9 x 10^5 tons = ? ounces
58. 1.35 kilometers per second = ? miles per hour
59. A city that uses ten billion BTUs of energy each month is using how many kilowatt-hours of energy?
60. A 340 million square mile forest is how many hectares?
61. If one barrel of crude oil provides six million BTUs of energy, how many BTUs of energy will one liter of crude oil provide?
62. Fifty eight thousand kilograms of solid waste is equivalent to how many metric tons?

Using Data to Plot a Graph

63. Graphing Practice Problem: The thickness of the annual tree rings indicate what type of environmental situation was occurring during that year of a tree's development. A thin ring usually indicates a challenging period of development. Lack of water, forest fires, or a major insect infestation will lessen tree growth. A thick ring indicates the opposite, environmental conditions that support tree growth.

Tree Age (years)	Average Thickness of Annual Rings in Forest A (centimeters)	Average Thickness of Annual Rings in Forest B (centimeters)
10	2.0	2.2
20	2.2	2.5
30	3.5	3.6
35	3.0	3.8
50	4.5	4.0
60	4.3	4.5

A. Design a line graph to analyze the provided data.
B. What is the dependent variable?
C. What is the independent variable?
D. Estimate the average thickness of the annual rings of 40 year old trees in Forest A.
E. Based on this data, what can you conclude about Forest A and Forest B?

Part II: AP Environmental Scholarly Article

DIRECTIONS: Annotate the text by **underlining** passages that are important, striking, or confusing. Add a **checkmark** and a short **summary** next to important parts of the text, an **exclamation point** and your **reaction** to striking portions of the text, and write a **question mark** and your **question** next to confusing parts of the text. Answer the ***Analysis Questions*** after reading.

NATIONAL GEOGRAPHIC MAGAZINE

Enter the Anthropocene—Age of Man

It's a new name for a new geologic epoch—one defined by our own massive impact on the planet. That mark will endure in the geologic record long after our cities have crumbled.

By Elizabeth Kolbert – March 2011

The path leads up a hill, across a fast-moving stream, back across the stream, and then past the carcass of a sheep. In my view it's raining, but here in the Southern Uplands of Scotland, I'm told, this counts as only a light drizzle, or smirr. Just beyond the final switchback, there's a waterfall, half shrouded in mist, and an outcropping of jagged rock. The rock has bands that run vertically, like a layer cake that's been tipped on its side. My guide, Jan Zalasiewicz, a British stratigrapher, points to a wide stripe of gray. "Bad things happened in here," he says.

The stripe was laid down some 445 million years ago, as sediments slowly piled up on the bottom of an ancient ocean. In those days life was still confined mostly to the water, and it was undergoing a crisis. Between one edge of the three-foot-thick gray band and the other, some 80 percent of marine species died out, many of them the sorts of creatures, like graptolites, that no longer exist. The extinction event, known as the end-Ordovician, was one of the five biggest of the past half billion years. It coincided with extreme changes in climate, in global sea levels, and in ocean chemistry—all caused, perhaps, by a supercontinent drifting over the South Pole.

Stratigraphers like Zalasiewicz are, as a rule, hard to impress. Their job is to piece together Earth's history from clues that can be coaxed out of layers of rock millions of years after the fact. They take the long view—the extremely long view—of events, only the most violent of which are likely to leave behind clear, lasting signals. It's those events that mark the crucial episodes in the planet's 4.5-billion-year story, the turning points that divide it into comprehensible chapters.

So it's disconcerting to learn that many stratigraphers have come to believe that *we* are such an event—that human beings have so altered the planet in just the past century or two that we've ushered in a new epoch: the Anthropocene. Standing in the smirr, I ask Zalasiewicz what he thinks this epoch will look like to the geologists of the distant future, whoever or whatever they may be. Will the transition be a moderate one, like dozens of others that appear in the record, or will it show up as a sharp band in which very bad things happened—like the mass extinction at the end of the Ordovician?

That, Zalasiewicz says, is what we are in the process of determining.

The word "Anthropocene" was coined by Dutch chemist Paul Crutzen about a decade ago. One day Crutzen, who shared a Nobel Prize for discovering the effects of ozone-depleting compounds, was sitting at a scientific conference. The conference chairman kept referring to the Holocene, the epoch that began at the end of the last ice age, 11,500 years ago, and that—officially, at least—continues to this day.

"'Let's stop it,'" Crutzen recalls blurting out. "'We are no longer in the Holocene. We are in the Anthropocene.' Well, it was quiet in the room for a while." When the group took a coffee break, the Anthropocene was the main topic of conversation. Someone suggested that Crutzen copyright the word.

Way back in the 1870s, an Italian geologist named Antonio Stoppani proposed that people had introduced a new era, which he labeled the anthropozoic. Stoppani's proposal was ignored; other scientists found it unscientific. The Anthropocene, by contrast, struck a chord. Human impacts on the world have become a lot more obvious since Stoppani's day, in part because the size of the population has roughly quadrupled, to nearly seven billion. "The pattern of human population growth in the twentieth century was more bacterial than primate," biologist E. O. Wilson has written. Wilson calculates that human biomass is already a hundred times larger than that of any other large animal species that has ever walked the Earth.

In 2002, when Crutzen wrote up the Anthropocene idea in the journal *Nature*, the concept was immediately picked up by researchers working in a wide range of disciplines. Soon it began to appear regularly in the scientific press. "Global Analysis of River Systems: From Earth System Controls to Anthropocene Syndromes" ran the title of one 2003 paper. "Soils and Sediments in the Anthropocene" was the headline of another, published in 2004.

At first most of the scientists using the new geologic term were not geologists. Zalasiewicz, who is one, found the discussions intriguing. "I noticed that Crutzen's term was appearing in the serious literature, without quotation marks and without a sense of irony," he says. In 2007 Zalasiewicz was serving as chairman of the Geological Society of London's Stratigraphy Commission. At a meeting he decided to ask his fellow stratigraphers what they thought of the Anthropocene. Twenty-one of 22 thought the concept had merit.

The group agreed to look at it as a formal problem in geology. Would the Anthropocene satisfy the criteria used for naming a new epoch? In geologic parlance, epochs are relatively short time spans, though they can extend for tens of millions of years. (Periods, such as the Ordovician and the Cretaceous, last much longer, and eras, like the Mesozoic, longer still.) The boundaries between epochs are defined by changes preserved in sedimentary rocks—the emergence of one type of commonly fossilized organism, say, or the disappearance of another.

The rock record of the present doesn't exist yet, of course. So the question was: When it does, will human impacts show up as "stratigraphically significant"? The answer, Zalasiewicz's group decided, is yes—though not necessarily for the reasons you'd expect.

Probably the most obvious way humans are altering the planet is by building cities, which are essentially vast stretches of man-made materials—steel, glass, concrete, and brick. But it turns out most cities are not good candidates for long-term preservation, for the simple reason that they're built on land, and on land the forces of erosion tend to win out over those of sedimentation. From a geologic perspective, the most plainly visible human effects on the landscape today "may in some ways be the most transient," Zalasiewicz has observed.

Humans have also transformed the world through farming; something like 38 percent of the planet's ice-free land is now devoted to agriculture. Here again, some of the effects that seem most significant today will leave behind only subtle traces at best.

Fertilizer factories, for example, now fix more nitrogen from the air, converting it to a biologically usable form, than all the plants and microbes on land; the runoff from fertilized fields is triggering life-throttling blooms of algae at river mouths all over the world. But this global perturbation of the nitrogen cycle will be hard to detect, because synthesized nitrogen is just like its natural equivalent. Future geologists are more likely to grasp the scale of 21st-century industrial agriculture from the pollen record—from the monochrome stretches of corn, wheat, and soy pollen that will have replaced the varied record left behind by rain forests or prairies.

The leveling of the world's forests will send at least two coded signals to future stratigraphers, though deciphering the first may be tricky. Massive amounts of soil eroding off denuded land are increasing sedimentation in some parts of the world—but at the same time the dams we've built on most of the world's major rivers are holding back sediment that would otherwise be washed to sea. The second signal of deforestation should come through clearer. Loss of forest habitat is a major cause of extinctions, which are now happening at a rate hundreds or even thousands of times higher than during most of the past half billion years. If current trends continue, the rate may soon be tens of thousands of times higher.

Probably the most significant change, from a geologic perspective, is one that's invisible to us—the change in the composition of the atmosphere. Carbon dioxide emissions are colorless, odorless, and in an immediate sense, harmless. But their warming effects could easily push global temperatures to levels that have not been seen for millions of years. Some plants and animals are already shifting their ranges toward the Poles, and those shifts will leave traces in the fossil record. Some species will not survive the warming at all. Meanwhile rising temperatures could eventually raise sea levels 20 feet or more.

Long after our cars, cities, and factories have turned to dust, the consequences of burning billions of tons' worth of coal and oil are likely to be clearly discernible. As carbon dioxide warms the planet, it also seeps into the oceans and acidifies them. Sometime this century they may become acidified to the point that corals can no longer construct reefs, which would register in the geologic record as a "reef gap." Reef gaps have marked each of the past five major mass extinctions. The most recent one, which is believed to have been caused by the impact of an asteroid, took place 65 million years ago, at the end of the Cretaceous period; it eliminated not just the dinosaurs, but also the plesiosaurs, pterosaurs, and ammonites. The scale of what's happening now to the oceans is, by many accounts, unmatched since then. To future geologists, Zalasiewicz says, our impact may look as sudden and profound as that of an asteroid.

If we have indeed entered a new epoch, then when exactly did it begin? When did human impacts rise to the level of geologic significance?

William Ruddiman, a paleoclimatologist at the University of Virginia, has proposed that the invention of agriculture some 8,000 years ago, and the deforestation that resulted, led to an increase in atmospheric CO_2 just large enough to stave off what otherwise would have been the start of a new ice age; in his view, humans have been the dominant force on the planet practically since the start of the Holocene. Crutzen has suggested that the Anthropocene began in the late 18th century, when, ice cores show, carbon dioxide levels began what has since proved to be an uninterrupted rise. Other scientists put the beginning of the new epoch in the middle of the 20th century, when the rates of both population growth and consumption accelerated rapidly.

Zalasiewicz now heads a working group of the International Commission on Stratigraphy (ICS) that is tasked with officially determining whether the Anthropocene deserves to be incorporated into the geologic timescale. A final decision will require votes by both the ICS and its parent organization, the International Union of Geological Sciences. The process is likely to take years. As it drags on, the decision may well become easier. Some scientists argue that we've not yet reached the start of the Anthropocene—not because we haven't had a dramatic impact on the planet, but because the next several decades are likely to prove even more stratigraphically significant than the past few centuries. "Do we decide the Anthropocene's here, or do we wait 20 years and things will be even worse?" says Mark Williams, a geologist and colleague of Zalasiewicz's at the University of Leicester in England.

Crutzen, who started the debate, thinks its real value won't lie in revisions to geology textbooks. His purpose is broader: He wants to focus our attention on the consequences of our collective action—and on how we might still avert the worst. "What I hope," he says, "is that the term 'Anthropocene' will be a warning to the world."

Analysis Questions

1. Select 3 passages, which best articulate why the current time period can be identified as a unique geological epoch, the Anthropocene. Draw a **box** around the text of each passage and **number** each passage (a minimum of 2-4 sentences per passage).

2. Which human activities are most likely to leave a mark in the geological record, and what kind of marks will each leave? Why are some activities expected to leave a much more clear and lasting mark than others?

3. How is this article related to the Synthesis Question: *Is it possible to provide the type of lifestyle currently enjoyed by people in developed countries for everyone on Earth in a sustainable way?*

AP Environmental Science Text: Name ________________________

Access the textbook at:
https://books.google.com/books?id=RIIq1r9dY0sC&printsec=frontcover#v=onepage&q&f=false
and read Chapter One (pages 1-25). While reading, complete the guide below.

Chapter 1: The State of Our Earth
Reading Guide
Vocabulary

Learn the definition of each term. The **bold** words require that you know more than just the definition. For example, *ecosystem service*: you should explain what it is, be able to name several examples, and describe the benefits of those services. You may want to use the following Quizlet to assist you:
https://quizlet.com/6189063/apes-friedland-ch-1-flash-cards/

System
Ecosystem
Biotic
Abiotic
Ecosystem Services
Environmental Indicators
Sustainability
Biodiversity
Genetic Diversity
Species Diversity
Ecosystem Diversity
Speciation
Background Extinction Rate
Greenhouse Gases
Anthropogenic
Sustainable Development
Ecological Footprint
Scientific Method
Hypothesis
Null Hypothesis
Replication
Sample Size
Accuracy
Precision
Uncertainty
Inductive Reasoning
Deductive Reasoning
Theory
Natural Law
Control Group
Natural Experiment
Environmental Justice

The Mysterious Neuse River Fish Killer

1. What is Pfiesteria?

2. What does Pfiesteria do to humans? Fish?

3. What triggers the Pfiesteria change from a harmless algae feeder to a toxin producing fish killer?

4. What are three important lessons that can be learned from the Neuse River Mystery?

1.1 Environmental Science Offers Important Insights into Our World

5. Explain how the Neuse River is part of a larger system.

6. Fill in the chart below to learn about biotic and abiotic factors

Factor	Abiotic (A) or Biotic (B)	If abiotic, describe one biotic factor that is influenced by or impacted by the factor	If biotic, describe one abiotic factor that is influenced by or impacted by the factor
Sunlight			
Bacteria			
Water temperature			
Trees			
Soil nutrients			

1.2 Humans Alter Natural Systems

7. How does new technology generally impact resource use?

8. Who uses more resources per capita: a child born in Los Angeles or a child born in rural India? Why?

1.3 Scientists Monitor Natural Systems for Signs of Stress

9. Fill out the following chart about the five global environmental indicators outlined in Table 1.2 and pages 5-11

Indicator	**Increasing, decreasing or staying the same right now?**	**To achieve sustainability, does it need to increase, decrease or stay the same in the future?**	**Why should you (personally) care about this indicator?**	**How does this indicator connect to ONE other indicator?**
Biological Diversity				
Food production				
Average Global Temperature and [CO_2]				
Human Population				
Resource depletion				

1.4 Human Well-Being Depends on Sustainable Practices

10. What happened on Easter Island, and what should be learned from their mistakes?

11. Pick a resource that you use on a daily basis (food, gasoline, paper, etc.), and describe how that resource could be used sustainably and unsustainably.

12. List 10 things you **<u>need</u>** in order to survive, and be a happy, well adjusted human being.

1.5 Science is a Process

13. Complete Free-Response Question (FRQ) #1 on page 24. Identify and label each part of your response as you answer it.

1.6 Environmental Science Presents Unique Challenges

14. Why is it more difficult to study environmental science that other science disciplines, such as biology and chemistry?

15. What is environmental justice, and why should all persons be concerned about it?

Answer M/C questions 1-10 on page 23-24

1. _______ 2. ___________ 3. ___________ 4. _________ 5.__________

6. ________ 7.___________ 8. ____________ 9. __________ 10. _________

Now go outdoors and spend time observing nature!

Introduction to Journaling & Observation
https://www.usanpn.org/intro-pheno-journal

Outdoor Action Guide to Nature Observation & Stalking
(A detailed guide for serious observers.)
https://www.princeton.edu/~oa/nature/naturobs.shtml