ART JOHNSON

Historical Roots of Our Calendar

HAVE YOU EVER NOTICED ANYTHING unusual about the names of some of the months? An *oct*opus has eight arms and an *oct*agon has eight sides, but *Oct*ober is not the eighth month, it is the tenth. The same is true of December. A *dec*imal is based on tenths, and a *dec*ade has ten years, but *Dec*ember is not the tenth month, it is the twelfth. A persistent myth tries to explain this discrepancy, suggesting that July and August were added to our calendar by Roman emperors Julius Caesar and Augustus Caesar, which shifted the rest of the months ahead by two places. There is some truth to this statement, but only a little. The month of July was not added to the calendar by Julius Caesar. Originally, July was named *Quintilis.* The Roman Senate renamed Quintilis for Julius Caesar after his assassination. The Roman Senate voted to do the same for the next emperor, Octavian, renaming the month *Sextilis* with the title it bestowed on him, which was Augustus, or *August.* Did you catch the original Latin names for these renamed months? *Quintilis* means "five," and *Sextilis* refers to "six." These months are also out of place as are the other months that follow. What happened to the order of the months and the origin of our present-day calendar is an interesting story.

The foundations of our modern calendar began with Julius Caesar. For several centuries before Caesar, the Roman calendar was 355 days, with a month that contained 22 or 23 days (known as Mercedinus) added at irregular intervals to bring the Roman year up to the solar equivalent of 365 1/4 days per year. By Caesar's time, 46 B.C.E., this extra month had been added so erratically that spring festivals were being celebrated in late fall. Caesar appointed an astronomer named Sosigenes to properly adjust the calendar. Sosigenes determined the number of days needed to synchronize the Roman calendar with the seasons. The adjustment required a year of 445 days! The year 46 B.C.E. became known as the Year of Confusion, the year with 445 days. To avoid this type of problem in the future, Sosigenes

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invented the scheme of adding a day every fourth year to keep the calendar accurate.

The start of the next year, 45 B.C.E., began on the first full moon after the winter solstice, December 21, in early January. Previously, January and February had been the last two months in the calendar, but now they were the first months. Since Sosigenes had not changed any names of the months, this new calendar's months were two places later than their names suggested. October was no longer the eighth month; it was now the tenth. December was no longer the tenth month; it was now the twelfth. This new calendar was named the Julian calendar in honor of Julius Caesar.

Some decades later, Augustus Caesar tinkered a bit with the Julian calendar. He suspended leap years for a few decades to further align the calendar with the seasons. He also changed the number of days in some of the months. Originally, the Roman Senate wanted to name his birth month, Septembris, after him but Augustus decided on Sextilis. But Sextilis was only thirty days long, and Julius Caesar had a thirty-one-day month named after him. Determined not to be outdone by Julius Caesar, Augustus resolved the problem by adding one day to his namesake month, August. Since the length of August matched the length of July, both men were equally honored. The extra day was taken from February, which was left with only twenty-eight days in a non–leap year. Augustus also took a day from September and November and added them to October and December. After this last tinkering occurred, the Julian calendar remained unchanged for the next fifteen centuries, keeping fairly accurate time. The yearly error was a loss of only eleven minutes, forty-five seconds each year, which was hardly noticeable. However, the accumulated time loss over the centuries became so obvious that a new calendar scheme had to be designed.

As early as 1545, Pope Paul III had observed that the spring equinox of March 21 or 22 actually occurred ten days earlier than the calendar indicated. An accurate date for the spring equinox was critical if the Church was to set the correct dates for Easter celebrations. In the 1560s, Pope Pius V called for this problem to be addressed at the Council of Trent. Although the Council did not resolve the problem, it did establish the need to firmly fix the spring equinox and to design a more accurate calendar. This task to develop a new calendar fell to Pius's successor, Pope Gregory XIII. Gregory XIII had been a delegate to the Council of Trent and was still interested in calendar reform.

In 1572, Gregory XIII assembled a group of mathematicians and astronomers to design a new calendar. The commission was lead by astronomer Aloysius Lilius and mathematician Christopher Clavius. The commission found that the Julian calendar was now approximately ten days behind real time. How could it be fixed? Lilius suggested making up the ten days gradually over the next forty years; Clavius suggested making up all ten days at once. Clavius's idea prevailed.

Thursday, October 4, 1582, was a most unusual day. It was immediately followed by Friday, October 15! As might be imagined, such a decree was not easily accepted. Bankers were unsure how to charge interest for a ten-day period that lasted one day. What would happen to debts due during the skipped days? How old would a person be who missed a birthday during those days? Were lives shortened by moving up the calendar? These and many other questions took months to work out, but the new version, named the Gregorian calendar after Pope Gregory XIII, was not used in most of Europe. However, by 1585, all Catholic countries in Europe had adopted it. Other countries eventually discarded the Julian calendar for this newer version. By the time that England adopted the Gregorian calendar in 1752, an additional day had to be added because the Julian calendar was now eleven days behind real time. The same concerns were raised in England that had been raised during the ten-day gap in Europe 170 years earlier. An upside to all this confusion was illustrated by Ben Franklin's remarks in *Poor Richard's Almanac:* "And what an indulgence is here for those who love their pillow to lie down in peace on the second of this month and not perhaps awake till the morning of the fourteenth." More than 150 years passed before China adopted the Gregorian calendar in 1912. Greece adopted it in 1923.

The Gregorian calendar's leap-year policy means that it is accurate to within 26 seconds per year

How did Lilius and Clavius redesign the new calendar to avoid the problems of the Julian calendar? The solution is leap year. Under the Julian calendar, every fourth year is a leap year. After fifteen centuries, this situation resulted in a ten-day loss to real time. The Gregorian calendar would observe leap years, but with a difference. Only century years divisible by 400 were leap years. Thus, 2000 is a leap year, but 2100 is not a leap year. Our Gregorian calendar is accurate to within about twenty-six seconds per year. At this rate, we will not need to add an adjustment day until the fourth millennium! ☞

Teacher Notes and Solutions to the Student Activity Sheet

QUESTIONS 1–7 ARE DESIGNED TO ENABLE STUdents to see the connections between various measurements of time. It also reviews standard operations and percents.

1. 365 days
2. 24 hours; 8760 hours
3. 60 minutes; 525,600 minutes
4. 60 seconds; 31,536,000 seconds
5. 26/3,153,600 ≈ 0.0000082, or about 0.00082%
6. 3,153,600/26 ≈ 121,292
7. If a generation is 30 years, 121,292/30 = 4043.1 years will pass before that additional year is needed.

Question 8 provides an opportunity for students to use multiplication, factoring, and critical-thinking skills.

8. Only two calendars are possible, because the only factors of 365 are 5 and 73. You might have a calendar with 5 months, containing 73 days each or a calendar with 73 months, containing 5 days each.

Questions 9–12 enable students to begin to understand how numbers on a calendar are related. It also introduces students to number theory.

9. The numbers are multiples of 7.
10. All these numbers have a remainder of 1 when divided by 7.
11. Each column of numbers has the same remainder when divided by 7, because 7 days are in each row.

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Student Activity Sheet

NAME ________________________________

Let's determine the length of a year using different units of measure. Note: We will assume that the year we are measuring is *not* a leap year.

1. A year has __________ days.

2. Each day has __________ hours, so a year has __________ hours.

3. Each hour has __________ minutes, so a year has __________ minutes.

4. Each minute has __________ seconds, so a year has __________ seconds.

Recall that the Gregorian calendar is accurate to within about 26 seconds per year.

5. Approximately what percent of a year is 26 seconds? __________________

6. Approximately how many years will it take for the 26 seconds to add up to an entire day? ________

7. Biologists vary in their definition of a generation. If we assume that a generation is 30 years, how many generations will pass before that additional year is needed? _____________________

8. Create a new calendar for our year of 365 days. However, each month must have the same number of days. How many different calendars with this property can you devise?

The calendar for every month has interesting characteristics. Let's explore some of them by examining the calendar for January 2002. The area of mathematics that studies these types of relationships is called *number theory.*

S	M	T	W	T	F	S
		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		

9. Consider the first Monday of the month, which is January 7. Look at all the numbers in this column. What do they have in common?

10. Consider Tuesday, January 8, 2002. Divide 8 by 7. What is the remainder? Now look at all the other numbers in this column. Divide each number by 7 and find the remainder. What do all these numbers have in common?

11. Try another column of numbers in the calendar. What do they have in common? Can you explain why each column of numbers has this common characteristic?