

Cosmic Calendar

Activity H2

Grade Level: 6–12



Source: The Cosmic Calendar is adapted with permission from Carl Sagan’s book *The Dragons of Eden* (copyright © 1977 by Carl Sagan) and from his television series *Cosmos*. This version was first written by Therese Puyau Blanchard and the staff of the Astronomical Society of the Pacific in 1994 and later revised and updated by Andrew Fraknoi. © copyright 2010 Astronomical Society of the Pacific: www.astrosociety.org

What’s This Activity About?

Students (and adults) have a lot of trouble envisioning the history of the universe, from the Big Bang, 13.7 billion years ago, through the development of various structures in the cosmos and the evolution of life on Earth, to the present moment. In this activity, students will equate the full span of cosmic time with one calendar year, and see where different cosmic events fall on a 12-month time scale.

What Will Students Do?

Students first brainstorm about the key events in the history of the universe and then put them in order. They will use a 12-month calendar hung from a clothesline or posted on the wall to show the whole class their estimates of what the order of events is and when each event falls on the “cosmic calendar.” Younger students then uncover the answer for some key events. Older students are given the instructions and a worksheet to figure out the answers for themselves.

Tips and Suggestions

- Most teachers are content to have students calculate the first entries in the time line to an accuracy of one day. However, if you are emphasizing the math component of the activity you can figure out the remainder (the fractional part of the day) and then convert these to hours, minutes, seconds.
- The later entries, involving human activities, do require calculating much smaller units of time. See the hints and answer key for teachers which is part of the activity.
- Some geology and earth science teachers do this activity using the history of our planet Earth as equal to one year. Once they understand the idea of such a calendar by analogy activity, students can make their own calendar for Earth history.

What Will Students Learn?

Concepts

- The Big Bang
- History of the Universe
- Ratios

Inquiry Skills

- Ordering
- Calculating
- Organizing
- Visualizing

Big Ideas

- Scale
- Evolution
- Models and simulations

Cosmic Calendar

by Therese Puyau Blanchard, Andrew Fraknoi,
and the staff of the Astronomical Society of the Pacific



Astronomers estimate that the universe began some 13.7 billion years ago in the explosion of space, time, matter, and energy we call the Big Bang. Such a number is hard to visualize. Most students have difficulty grasping how large a span of time this is compared to their own lifetimes or to the events they read about in history.

One way to visualize large expanses of astronomical time is to draw an analogy between the time since the creation of the cosmos and a more familiar span of time, like a year. Geology educators have used this technique for a while, but in astronomy the idea was pioneered by Cornell University astronomer and popularizer of science, Carl Sagan. In Chapter 1 of his Pulitzer-prize winning book, *The Dragons of Eden* (1977, Random House hard cover; Ballantine paperback), Sagan proposed compressing the history of the universe into one year and then seeing where in that year various events of interest fall. Since the book was written, we have better information about a number of the time spans Sagan originally used, but the technique of figuring out “the cosmic year” remains a particularly powerful educational tool.

Depending on the age and mathematical ability of the students or audience, you can either provide the dates for this visual analogy or have students calculate them. The necessary information and materials for both options are provided below.

Materials Needed:

- 12-month calendar (either one for the whole class or one for each group; the larger the better)
- Clothesline and clothespins (optional, but recommended)
- Large cards or signs for each major event, with the date of the event written on the back (covered by a sheet of paper) [*for older students, let them make these*

cards or signs instead of providing them]

- Cosmic Calendar Events hand-outs
- A large sheet of construction paper for each group of students
- Glue
- Scissors
- Blank sheets of paper
- (*Optional, for students doing calculations*) Cosmic Time Line Events Worksheet, Cosmic Time Line Events Calculations Sheet, and Backward Calendar Count Table

Procedures

1. Present the concept of a time line by displaying the 12-month calendar, with the months hung along a wall or across the room on a clothes line. (The clothes-line calendar strung along the whole classroom allows step 6 to be especially dramatic.)
2. Explain the visual analogy: that the first moment of January 1st of our one-year “Cosmic Calendar” represents the “Big Bang,” which is the beginning of cosmic time. Explain that “today” is represented by the last possible moment on December 31st. Thus, this “cosmic year” represents the entire history of the universe. Now we want to see where different historical events fall on our calendar of cosmic time.
3. Depending on your students’ background, either brainstorm with them or divide them into small groups to brainstorm about some of the important events that happened between the Big Bang and now. Encourage them to take a “big picture view” and focus some of their attention on events in the universe at large and not just those on Earth. Accept all suggestions at first to be sure everyone gets a chance to participate and then have them narrow down the number of events to

be manageable.

4. If you have not done so already, now divide the class into groups and distribute a Cosmic Calendar Events handout to each group. Have groups cut and place the list of events on the handout onto the large piece of construction paper to create one long time line. (*Note: There is nothing sacred about this particular list of events. You can give students a shorter list, a longer list, or a different list, depending on their backgrounds and your curriculum. Later, you can have them do research and find how long ago events that they add to the list happened.*)

5. Each group should then take the major events listed on the Cosmic Calendar Events hand-out and decide on the probable *order* of occurrence by putting the events in the right sequence. When every group has decided on the order of the events, you can have a full-class discussion and see if groups agreed on the order. Groups can adjust their own order based on the full-class discussion.

6. Now we want to become more specific and try to figure out where each event would actually fit within our “cosmic year.” So, for example, where in the year would the origin of planet Earth lie? Would it be early in January, in the spring, in the fall, etc? If each group has its own 12-month calendar, have the groups place each event they cut out next to the month they predict the event occurred. Groups that finish first can also try to predict the day of the month for some events. (If there is only one calendar for the whole room, then just have students keep notes on the months and dates they predict; perhaps by pasting each event to a sheet of blank paper and writing their estimate of the month and day in pencil on the sheet.)

7. Then, select volunteers to be a “living time line.” Give each volunteer a larger sign or picture for one of the major events (these signs need to be prepared in advance; on the back you can put the correct Cosmic Calendar date for that event and then cover it up with a flap, or just leave the answer for later). Ask volunteers to stand under the predicted month on the clothesline calendar or next to the month on the wall calendar for their event. (*At this point, the class is still using their own estimates for where each event falls on the calen-*

dar, and has not yet been given the answers.) When the volunteers have found their places, each one should say their event and their estimate of the date aloud, starting with the earliest.

8. Hold a class discussion on the order of the events portrayed. A student who disagrees with the order or placement of a certain event may change places with the person holding that card, if the class agrees. Continue the discussion until a majority of the students agree with the order of events.

9. Now it’s time to see how well the students did. For younger students, if the large sign or poster each volunteer in the “living time line” is holding has the “answer” under the flap on the back, have them uncover the answer and read aloud the actual calendar date for that event one by one. If necessary have them re-position themselves on the time line. Leave time for discussion, especially for those event dates where students were considerably off.

10. For older students, have the volunteers write their estimates for each event in pencil on the class calendar. Then have everyone sit down and assign different groups to do the calculations of where various key events fall on the time-line. Have them use the Cosmic Time Line Events Worksheet in this activity. Instructions for doing the math are on the Cosmic Time Line Events Calculations Sheet. Once the answers are done, volunteers should go back up to the class calendar and correct any estimates that need correcting and re-position themselves. Leave time for discussion.

11. Point out some of the significant events and discuss these questions:

- Humans arrived on the scene only about 8 minutes ago according to our model. How does this change your perspective on our cosmic importance?
- Dinosaurs ruled the Earth for almost two hundred million years— from December 26 to December 30 on our time line. They died out long before humans came on the scene. Does this change your thinking about dinosaurs?
- Were you surprised by when the Earth and the Sun were formed in the “cosmic year? If there are older stars than the Sun out there (and there are many),

might they have older life-forms on them?

- It took a long time between the beginning of life on Earth and the rise of humans. Did you think before this activity started that the time for us to evolve was that long?

*NOTE: It's important for students to understand that science is a "progress report" and is always updated as new experiments and observations become possible. While the dates in the attached worksheet are our **current** best estimates, new information may become available about some of the ideas presented in the table. Older students may want to do some research using reliable web sites and books about the latest estimates.*

Extensions

1. Have students write up and illustrate their own cosmic time lines in their notebooks, and include information and scale drawings.
2. Have students work in groups to design mobiles using hangers and string to fit the events on the class clothesline.
3. Do research to find additional events for the time line. If necessary, enlarge a part of the Cosmic Calendar to study shorter time periods. Other events could include: first life on land, first primates, the invention of writing, etc.
4. Designate an entire hall in the school as a cosmic time line. Have students create drawings and captions to describe the major events and hang these along the time line. Have one group make a poster to explain the time line concept to other students in the school.

Note for the Teacher or Activity Leader

We have included a Cosmic Time Line Events Worksheet with Answers for your use. In the calendar calculations,

1 calendar day = 37.5 million years

1 calendar hour = 1.56 million years

1 calendar minute = 26,050 years

1 calendar second = 434 years.

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Cosmic Calendar Events Handout

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The Big Bang

The formation of first neutral atoms

Formation of first stars & galaxies

Formation of the thin disk of the Milky Way Galaxy

Formation of the Solar System

Formation of the Moon

Birth of life on Earth

First cells develop on Earth

First vertebrates (creatures with backbones)

First dinosaurs

First mammals

Death of the dinosaurs from giant impact

First bipedal hominids

(human-like creatures walking on two legs)

First humans (homo sapiens)

Development of agriculture (farming)

Development of the wheel for transportation

Invention of the telescope

Right now

Cosmic Time Line Events Worksheet

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Note: The symbol ~ in front of a number means “roughly” or “about”

Event	Number of Years Ago	Number of Days Ago on Calendar	Date/Time on Calendar
The Big Bang	13.7 billion	365	Jan. 1, 12 am
The formation of first neutral atoms	13.7 billion (400,000 years after the BB)	365	Jan. 1, 12:15 am
Formation of first stars & galaxies	~13 billion		
Formation of the thin disk of the Milky Way Galaxy	~9 billion		
Formation of the Solar System	4.56 billion		
Formation of the Moon	~4.5 billion		
Birth of life on Earth	~3.8 billion		
First cells develop on Earth	~2 billion		
First vertebrates (creatures with backbones)	~520 million		
First dinosaurs	230 million		
First mammals	~200 million		
Death of the dinosaurs from giant impact	65 million		
First bipedal hominids (human-like creatures walking on two legs)	~4 million		
First humans (homo sapiens)	200,000		
Development of agriculture (farming)	~10,000		
Development of the wheel for transportation	~6500		
Invention of the telescope	400		
Right now	0	0	Dec. 31, midnight

KEY: Cosmic Time Line Events Worksheet with Answers

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Note: The symbol ~ in front of a number means “roughly” or “about”

Event	Number of Years Ago	Number of Days Ago on Calendar	Date/Time on Calendar
The Big Bang	13.7 billion	365 days	Jan. 1, 12 am
The formation of first neutral atoms	13.7 billion (400,000 years after the BB)	365 days plus 15 min.	Jan. 1, 12:15 am
Formation of first stars & galaxies	~13 billion	~347 days	~Jan. 19
Formation of the thin disk of the Milky Way Galaxy	~9 billion	~240 days	~May 6
Formation of the Solar System	4.56 billion	122 days	Sep. 1
Formation of the Moon	~4.5 billion	~120 days	~Sep. 3
Birth of life on Earth	~3.8 billion	~101 days	~Sep. 22
First cells develop on Earth	~2 billion	~53 days	~Nov. 9
First vertebrates (creatures with backbones)	~520 million	~14 days	~Dec. 18
First dinosaurs	230 million	6 days	Dec. 26
First mammals	~200 million	~5 days	~Dec. 27
Death of the dinosaurs from giant impact	65 million	1.7 days	Dec. 30
First bipedal hominids (human-like creatures walking on two legs)	~4 million	~2.5 hrs	Dec. 31, ~9:30 pm
First humans (homo sapiens)	200,000	8 min	Dec. 31, 11:52 pm
Development of agriculture (farming)	~10,000	23 sec	Dec. 31, 11:59:37
Development of the wheel for transportation	~6500	~15 sec	Dec. 31, ~11:59:45
Invention of the telescope	400	1 sec	Dec 31, 1 second before midnight
Right now	0	0	Dec. 31, midnight

Cosmic Time Line Events Calculations

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In this exercise, we want to set the age of the universe equal to one calendar year. Then we want to set up ratios to figure out where in that calendar year significant events in the history of the universe would fall. (In this analogy, the Big Bang happens in the first moment of Jan. 1 and NOW is the very last moment of Dec. 31.)

So our basic idea is that 13.7 billion years equal one calendar year (365 days). We'll ignore leap years for this exercise.

We set up a ratio in the form:

$$\frac{\text{Number of years ago an event happened}}{\text{Number of years ago Big Bang happened}} = \frac{x \text{ days}}{365 \text{ days}}$$

The number of years ago the Big Bang happened is 13.7 billion years = 13,700 million years.

When you've solved for x, the number of days ago (from Dec. 31) that an event should be placed on our calendar, you then have to count the days backwards. To make that easier, we have provided a table that tells you on what date any number of days counted backwards from Dec. 31 would fall. (You're welcome.)

So, for example, the dinosaurs developed 230 million years ago. Setting up our equation,

$$\frac{230 \text{ million years}}{13,700 \text{ million years}} = \frac{x \text{ days}}{365 \text{ days}}$$

$$x = 6.13 \text{ days (which we round off to 6 days ago)}$$

Looking at the table of dates counted backwards, 6 days before the end of Dec. 31 puts the start of the dinosaurs on Dec. 26.

Use the table "Cosmic Time Line Events Worksheet" which lists some of the key events in the history of the universe and do the same kind of calculation for each event. At first, you can round off, but as you get to events closer to the end, fractions matter.

So we want to figure out how many years of real time would make an hour on our cosmic calendar. If 13.7 billion years = 1 calendar year, then one day on our calendar would be:

$$\frac{13,700 \text{ million yrs in a calendar year}}{365 \text{ days in a calendar year}} = 37.5 \text{ million years/calendar day}$$

In the same way, divide by 24 hours in a day to figure out the number of years in a calendar hour and divide by 60 again to get the number of years in a calendar minute.

Days of the Year*

Number of days before December 31st

	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
JAN	365	364	363	362	361	360	359	358	357	356	355	354	353	352	351	350	349	348	347	346	345	344	343	342	341	340	339	338	337	336	335
FEB	334	333	332	331	330	329	328	327	326	325	324	323	322	321	320	319	318	317	316	315	314	313	312	311	310	309	308	307			
MAR	306	305	304	303	302	301	300	299	298	297	296	295	294	293	292	291	290	289	288	287	286	285	284	283	282	281	280	279	278	277	276
APR	275	274	273	272	271	270	269	268	267	266	265	264	263	262	261	260	259	258	257	256	255	254	253	252	251	250	249	248	247	246	
MAY	245	244	243	242	241	240	239	238	237	236	235	234	233	232	231	230	229	228	227	226	225	224	223	222	221	220	219	218	217	216	215
JUN	214	213	212	211	210	209	208	207	206	205	204	203	202	201	200	199	198	197	196	195	194	193	192	191	190	189	188	187	186	185	
JUL	184	183	182	181	180	179	178	177	176	175	174	173	172	171	170	169	168	167	166	165	164	163	162	161	160	159	158	157	156	155	154
AUG	153	152	151	150	149	148	147	146	145	144	143	142	141	140	139	138	137	136	135	134	133	132	131	130	129	128	127	126	125	124	123
SEP	122	121	120	119	118	117	116	115	114	113	112	111	110	109	108	107	106	105	104	103	102	101	100	99	98	97	96	95	94	93	
OCT	92	91	90	89	88	87	86	85	84	83	82	81	80	79	78	77	76	75	74	73	72	71	70	69	68	67	66	65	64	63	62
NOV	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32	
DEC	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

*Does not take leap years into account.