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Kids will have fun learning about our solar system with these free printable Solar System Worksheets for kids. You'll find solar system vocabulary, planets, sun, stars, moon phases, and so much more! These free worksheets are great for Kindergarteners, grade 1, grade 2, grade 3, grade 4, grade 5, and grade 6 students. Solar System Worksheets Our solar system is a fascinating things for kids of all ages to study. Not only can they easily see the sun, they live on planet Earth, and they see bright stars in the evening sky. But there is so much more to it – a vast expanse of space filled with planets no man has ever walked on, mysteries like what is inside the earth, and so much more. It is no wonder even adults are fascinated with space travel, space exploration and science fiction shows like Star Trek and Star Wars. Our universe is truly an amazing and wonderful place. These solar system worksheets are a fun way to learn more about the milk way galaxy, mars, venus, Mercury, Jupiter, Saturn, Uranus, Neptune, the moon, and so much more! Whether you are a parent, teacher, or homeschooler – these free science worksheets are a great way to make learning fun. You will love that they are no prep! Use these with an astronomy or solar system unit with pre k, kindergarten, first grade, 2nd grade, 3rd grade, 4th grade, 5th grade, and 6th grade children. Don't miss our solar system project ideas, free science lessons, and free 5th grade worksheets! Free solar system printables I created these solar system worksheets free as part of our Solar System unit. Studying the solar system is a lot of fun. Kids have a natural interest in the stars, sun, planets, and more and this science unit is a great way to draw on kids natural curiosity and interest for a teachable moment. They are a great way to help reinforce what kids are reading / learning as well to ensure they are remembering what they are studying as well. You will love that they include a huge variety of resources to learn astronomy for kids vocabulary, moon face, moon phases, planets worksheet, planet order, and so much more! Solar system printables Start by scrolling to the bottom of the post, under the terms of use, and enter your information in the box and click PRINT. For current subscriber, you will be immediately redirected to the pdf file so you can save the freebie and print the pack. If you are a new reader, WELCOME! By entering your email address you will added to our free weekly newsletter filled with educational activities, fun ideas, and free printables to make leaning fun for kids from toddler-8th grade! Don't close the page, you will also get instant access to the free solar system worksheets. Solar system worksheet Included in these free printable solar system worksheets is what our family used to study the solar system. Of course we added some engaging books and hands on science projects too – you can see them in our solar system unit . There are 25 pages in this huge pack with a variety of levels to accommodate kids from Preschool – 8th grade. This is such a fun science unit to do together as a family! Solar system printable In the free printable free solar system worksheets you'll find the following different solar system worksheet: Solar system vocabulary (29 color cars) Solar system vocabulary quiz Label the Planets Planet Order (with mnemonic device) Sun Review Questions (and answers) Moon Review Questions (and answers) Inner Planets Review Questions (and answers) Outer Planets Review Questions (and answers) Label the Moon Phases Moon Observations Mercury Facts Venus Facts Mars Facts Jupiter Facts Saturn Facts Uranus Facts Neptune Facts Solar system for kids printables Looking for more fun, hands on science activities to teach kids about astronomy or to round out your solar system for kids unit. You will love these hands on solar system activities and lessons: The Sun Activities for Kindergarten – learn about the sun and how the planets orbit around it including a fun planets game for kids! Moon Activities for Kids & Astronauts Too – make oreo moon phases, DIY telescope, learn about the astronauts who landed on the moon, and more! Inner Planets for Kids (Mercury, Venus, Earth, Mars) – Use our free planet worksheets and fun hands-on activities like Mercury craters, Venus' melting rocks, layers of the earth, and Erupting Mars Volcano Outer Planets for Kids (Jupiter, Saturn, Uranus, Neptune) – combination of hands-on solar system projects and solar system printables; gaseous Jupiter, Saturn Rocket, plus cloudy Uranus and Neptune. Pluto, Asteroid Belt, Comets, and Stars for Kids – make a FUN constellation projector, cold Pluto ice cream project, and grape constellation project Yarn Solar System Project – fun, unique, and easy solar system model that is cheap and so pretty! Paint Stick Solar System Project – easy-to-make solar system model for kids that doubles as an activity for learning the names and order of the planets Pipe Cleaner Constellations – fun hands on pipe cleaner constellations activity for kids Simple Galaxy Science Experiments Looking for more fun, engaging, creative, and memorable moon projects for kids? You will love this 50 Moon Activities for Kids & Crafts collection with the best ideas from the whole internet! TONS of really cool Solar System Project Ideas for kids of all ages Solar system worksheets for kids Plus, don't forget to add these free solar system worksheets and printables to your lesson plan: Science for Kids Looking for lots more fun, science experiments for kids? You've GOT to try some of these outrageously fun science experiments for kids! We have so many fun, creative and easy science experiments for elementary age children: Free Printable Animal Classifications for Kids Cootie Catchers 19 Edible science experiments – which delicious project will you try first? HUGE Free Solar System Unit (coloring pages, hands on science projects, worksheets, and more!) Pipe Cleaner Constellation Activity (As seen on Good Housekeeping!) Teach kids about conductivity with this fun squishy circuits projects Amazing, Heat Sensitive, Color Changing Slime Life Cycles for Kids (from penguin to sunflower and spider to turkey we have LOTS of life cycles to explore and learn about) EASY, Colorful Oil and Water Science Experiment Kids will be amazed as you change colors of white flowers with this Dying Flowers Science Experiment This super cool Lego Zipline is fun and simple to make Human Body Project Check out this super cool look INSIDE a Volcano Project Exploding Watermelon – science experiment that explores potential and kinetic energy with a big WOW moment! Memorable Life Size Skeletal system science project – includes free printable template Mind-Blowing Magnetic Slime for Kids 5, 4, 3, 2, 1, BLAST OFF! Rocket Baking Soda and Vinegar Experiment Find LOTS more Easy Science Experiments for kids of all ages! Looking for some fun solar system books to add to your study? Check out these family favorites! Planet worksheets This is for personal use only (teachers please see my TPT store) This may NOT be sold, hosted, reproduced, or stored on any other site (including blog, Facebook, Dropbox, etc.) All materials provided are copyright protected. Please see Terms of Use. Graphics Purchased and used with permission I offer free printables to bless my readers AND to provide for my family. Your frequent visits to my blog & support purchasing through affiliates links and ads keep the lights on so to speak. Thanks you! Beth GordenBeth Gorden is the creative multi-tasking creator of 123 Homeschool 4 Me. As a busy homeschooling mother of six, she strives to create hands-on learning activities and worksheets that kids will love to make learning FUN! With over 20 years educating children, she has created over 1 million pages of printables to help teach kids alphabet, math, science, English grammar, history, and so much more! Beth is also the creator of 2 additional sites with even more educational activities and FREE printables – www.kindergartenworksheetsandgames.com and www.preschoolplayandlearn.com. Beth studied at the University of Northwestern where she got a double major to make her effective at teaching children while making education FUN! This is a free sample of the following product: Bill Nye THE SUN - Video Guide, Quiz, Sub Plan, Worksheets, No Prep, LessonThe full product is a PowerPoint presentation, video guide worksheet/quiz, and KWL chart. It includes: -PowerPoint Presentation -KWL Chart -Video Guide Worksheet -Answer Key FREE SAMPLEFor a free sample of this product check out: Bill Nye Science MOTION Video Guide, Quiz, Sub Plan, Worksheets, No Prep Lesson These worksheets can be used as a video guide to hold students acc , the free encyclopedia that anyone can edit. 110,144 active editors 7,022,728 articles in English Sirius A with Sirius B, a white dwarf, indicated by the arrow A white dwarf is a stellar core remnant composed mostly of electron-degenerate matter, supported against its own gravity only by electron degeneracy pressure. A white dwarf is very dense: in an Earth sized volume, it contains a mass comparable to the Sun. What light it radiates is from its residual heat. White dwarfs are thought to be the final evolutionary state of stars whose mass is insufficient for them to become a neutron star or black hole. This includes more than 97% of the stars in the Milky Way. After the hydrogen-fusing period of such a main-sequence star ends, it will expand to a red giant and shed its outer layers, leaving behind a core which is the white dwarf. This, very hot when it forms, cools as it radiates its energy until its material begins to crystallize into a cold black dwarf. The oldest known white dwarfs still radiate at temperatures of a few thousand kelvins, which establishes an observational limit on the maximum possible age of the universe. (Full article...) Recently featured: Battle of Groix Scott Carpenter Johann Reinhold Forster Archive By email More featured articles About A Royal 10 typewriter ... that a Royal 10 (pictured) used in the music video for "Fortnight" caused an interest in typewriters among Swifties? ... that the Brazilian government advocated the use of COVID kits, which contained a drug used to treat head lice? ... that Brave Bunnies was among the children's series streamed ad-free on Sunflower TV for Ukrainian refugees? ... that it took more than two years after the Romans invaded Africa in 204 BC for them to completely defeat the Carthaginians? ... that the Pittsburgh Post-Gazette reported that "half of the residents of Mount Desert Island, Maine, are convinced they are millionaires since the body of Karl N. Mellon" was discovered? ... that AiScReam's recent debut song "Ai Scream!" went viral on social media? ... that Laura LeRoy Travis was the first woman at the University of Delaware to coach a men's sports team? ... that the screenplay for Smashing Frank was developed from an assignment in a filmmaking course? ... that the iconic 1937 photograph At the Time of the Louisville Flood identifiably depicts neither Louisville nor the flood? Archive Start a new article Nominate an article Vera Rubin Observatory The Vera C. Rubin Observatory (pictured) in Chile releases the first light images from its new 8.4-metre (28 ft) telescope. In basketball, the Oklahoma City Thunder defeat the Indiana Pacers to win the NBA Finals. The United States conducts military strikes on three nuclear facilities in Iran. In rugby union, the Crusaders defeat the Chiefs to win the Super Rugby Pacific final. In ice hockey, the Florida Panthers defeat the Edmonton Oilers to win the Stanley Cup. Ongoing: Gaza war Iran–Israel war Russian invasion of Ukraine timeline Sudanese civil war timeline Recent deaths: Frederick W. Smith Ron Taylor Mohammad Kazemi Marita Camacho Quirós Kim Woodburn William Langewiesche Nominate an article June 24: Jaanipäev in Estonia Julia Gillard 1374 – An outbreak of dancing mania, in which crowds of people danced themselves to exhaustion, began in Aachen (in present-day Germany) before spreading to other parts of Europe. 1717 – The first Grand Lodge of Freemasonry, the Premier Grand Lodge of England, was founded in London. 1724 – On the Feast of St. John the Baptist, Bach led the first performance of Christ unser Herr zum Jordan kam, BWV 7, the third cantata of his chorale cantata cycle. 1943 – Amid racial tensions, U.S. Army military police shot and killed a black serviceman after a confrontation at a pub in Bamber Bridge, England. 2010 – Julia Gillard (pictured) was sworn in as the first female prime minister of Australia after incumbent Kevin Rudd declined to contest a leadership spill in the Labor Party. William Arnold (b. 1587)John Lloyd Cruz (b. 1983)Lisa (b. 1987)Rodrigo (d. 2000) More anniversaries: June 23 June 24 June 25 Archive By email List of days of the year About The springbok (Antidorcas marsupialis) is a medium-sized antelope found mainly in the dry areas of southern and southwestern Africa. A slender, long-legged bovid, it reaches 71 to 86 cm (28 to 34 in) at the shoulder and weighs between 27 and 42 kg (60 and 93 lb). Both sexes have a pair of long black horns that curve backwards, a white face, a dark stripe running from the eyes to the mouth, a light-brown coat with a reddish-brown stripe, and a white rump flap. Primarily browsing at dawn and dusk, it can live without drinking water for years, subsisting on succulent vegetation. Breeding peaks in the rainy season, when food is more abundant. A single calf is weaned at nearly six months of age and leaves its mother a few months later. Springbok herds in the Kalahari Desert and the semi-arid Karoo used to migrate in large numbers across the countryside. The springbok is the national animal of South Africa. This male springbok was photographed in Etosha National Park, Namibia. Photograph credit: Yathin S Krishnappa Recently featured: Geraldine Ulmar Shah Mosque (Isfahan) Cape Barren goose Archive More featured pictures Community portal – The central hub for editors, with resources, links, tasks, and announcements. Village pump – Forum for discussions about Wikipedia itself, including policies and technical issues. Site news – Sources of news about Wikipedia and the broader Wikimedia movement. Teahouse – Ask basic questions about using or editing Wikipedia. Help desk – Ask questions about using or editing Wikipedia. Reference desk – Ask research questions about encyclopedic topics. Content portals – A unique way to navigate the encyclopedia. Wikipedia is written by volunteer editors and hosted by the Wikimedia Foundation, a non-profit organization that also hosts a range of other volunteer projects: CommonsFree media repository MediaWikiWiki software development Meta-WikiWikimedia project coordination WikibooksFree textbooks and manuals WikidataFree knowledge base WikinewsFree-content news WikiquoteCollection of quotations WikisourceFree-content library WikispeciesDirectory of species WikiversityFree learning tools WikivoyageFree travel guide WiktionaryDictionary and thesaurus This Wikipedia is written in English. Many other Wikipedias are available; some of the largest are listed below. 1,000,000+ articles العربية Deutsch Español فارسی Français Italiano Nederlands 日本語 Polski Português Русский Svenska Українська Tiếng Việt 中文 250,000+ articles Bahasa Indonesia Bahasa Melayu Bân-lâm-gú Български Català Čeština Dansk Eesti Ελληνικά Esperanto Euskara עברית Հայերեն Magyar Norsk bokmål Română Simple English Slovenčina Srpski Srpskohrvatski Suomi Türkçe Oʻzbekcha 50,000+ articles Asturianu Azərbaycanca Bosanski کوردی Frysk Gaeilge Galego Hrvatski ქართული Kurdî Latviešu Lietuvių Македонски Norsk nynorsk Shqip Slovenščina اردو Retrieved from " 2 This article needs additional citations for verification. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed.Find sources: "1374" – news · newspapers · books · scholar · JSTOR (June 2017) (Learn how and when to remove this message) Calendar year Years Millennium 2nd millennium Centuries 13th century 14th century 15th century Decades 1350s 1360s 1370s 1380s 1390s Years 1371 1372 1373 1374 1375 1376 1377 vte 1374 by topic Leaders Political entities State leaders Religious leaders Birth and death categories Births – Deaths Establishments and disestablishments categories Establishments – Disestablishments Art and literature 1374 in poetry vte 1374 in various calendarsGregorian calendar1374MCCCLXXIVAb urbe condita2127Armenian calendar823ԹՎ ՊԻԳAssyrian calendar6124Balinese saka calendar1295–1296Bengali calendar780–781Berber calendar2324English Regnal year47 Edw. 3 – 48 Edw. 3Buddhist calendar1918Burmese calendar736Byzantine calendar6882–6883Chinese calendar癸丑年 (Water Ox)4071 or 3864 — to —甲寅年 (Wood Tiger)4072 or 3865Coptic calendar1090–1091Discordian calendar2540Ethiopian calendar1366–1367Hebrew calendar5134–5135Hindu calendars - Vikram Samvat1430–1431 - Shaka Samvat1295–1296 - Kali Yuga4474–4475Holocene calendar11374Igbo calendar374–375Iranian calendar752–753Islamic calendar775–776Japanese calendarŌan 7(応安７年)Javanese calendar1287–1288Julian calendar1374MCCCLXXIVKorean calendar3707Minguo calendar538 before ROC民前538年Nanakshahi calendar−94Thai solar calendar1916–1917Tibetan calendar阴水牛年(female Water-Ox)1500 or 1119 or 347 — to —阳木虎年(male Wood-Tiger)1501 or 1120 or 348Year 1374 (MCCCLXXIV) was a common year starting on Sunday of the Julian calendar. April 23 – In recognition of his services, Edward III of England grants the English writer Geoffrey Chaucer a gallon of wine a day, for the rest of his life. June 24 – The illness dancing mania begins in Aix-la-Chapelle (Aachen), possibly due to ergotism. October 27 – King Gongmin of Goryeo is assassinated and succeeded by U of Goryeo on the throne of Goryeo (in modern-day Korea). November 25 – James of Baux succeeds his uncle, Philip II, as Prince of Taranto (modern-day eastern Italy) and titular ruler of the Latin Empire (northern Greece and western Turkey). Rao Biram Dev succeeds Rao Kanhadev as ruler of Marwar (the modern-day Jodhpur district of India). Shaikh Hasan Jalayir succeeds his father, Shaykh Uways Jalayir, as ruler of the Jalayirid Sultanate in modern-day Iraq and western Iran. Hasan proves to be an unpopular ruler and is executed on October 9 and succeeded by his brother, Shaikh Hussain Jalayir. Musa II succeeds his father, Mari Djata II, as Mansa of the Mali Empire (modern-day Mali and Senegal). Robert de Juilly succeeds Raymond Berenger as Grand Master of the Knights Hospitaller. Princes from the Kingdom of Granada choose Abu al-Abbas Ahmad to succeed Muhammad as-Said, as Sultan of the Marinid Empire in Morocco. The Empire is split into the Kingdom of Fez and the Kingdom of Marrakech. A form of the Great Plague returns to Europe. The Château de Compiègne royal residence is built in France. April 11 – Roger Mortimer, 4th Earl of March, heir to the throne of England (d. 1398) November 26 – Yury Dmitrievich, Russian grand prince (d. 1434) probable Queen Jadwiga of Poland King Martin I of Sicily (d. 1409) March 12 – Emperor Go-Kōgon of Japan (b. 1338). June 5 or June 6 – William Whittlesey, Archbishop of Canterbury June 29 – Jan Milíč of Kroměříž, Czech priest and reformer July 19 – Petrarch, Italian poet (b. 1304) September – Joanna of Flanders, Duchess of Brittany (b. 1295) October 27 – King Gongmin of Goryeo (b. 1330) November 25 – Prince Philip II of Taranto December 1 – Magnus Eriksson, king of Sweden (b. 1316) date unknown – Gao Qi, Chinese poet (born 1336) date unknown – Konrad of Megenberg, historian (b. 1309)[1] ^ "Book of Nature". World Digital Library. August 7, 2013. Retrieved August 27, 2013. Retrieved from " 3One hundred years, from 1201 to 1300 For the video game series, see XIII Century (series). Millennia 2nd millennium Centuries 12th century 13th century 14th century Timelines 12th century 13th century 14th century State leaders 12th century 13th century 14th century Decades 1200s 1210s 1220s 1230s 1240s 1250s 1260s 1270s 1280s 1290s Categories: Births – Deaths Establishments – Disestablishments vte Mongol Emperor Genghis Khan whose conquests created the largest contiguous empire in history The 13th century was the century which lasted from January 1, 1201 (represented by the Roman numerals MCCI) through December 31, 1300 (MCCC) in accordance with the Julian calendar. The Mongol Empire was founded by Genghis Khan, which stretched from Eastern Asia to Eastern Europe. The conquests of Hulagu Khan and other Mongol invasions changed the course of the Muslim world, most notably the Siege of Baghdad (1258) and the destruction of the House of Wisdom. Other Muslim powers such as the Mali Empire and Delhi Sultanate conquered large parts of West Africa and the Indian subcontinent, while Buddhism witnessed a decline through the conquest led by Bakhtiyar Khilji. The earliest Islamic states in Southeast Asia formed during this century, most notably Samudera Pasai.[1] The Kingdoms of Sukhothai and Hanthawaddy would emerge and go on to dominate their surrounding territories.[2] Europe entered the apex of the High Middle Ages, characterized by rapid legal, cultural, and religious evolution as well as economic dynamism. Crusades after the fourth, while mostly unsuccessful in rechristianizing the Holy Land, inspired the desire to expel Muslim presence from Europe that drove the Reconquista and solidified a sense of Christendom. To the north, the Teutonic Order Christianized and gained dominance of Prussia, Estonia, and Livonia. Inspired by new translations into Latin of classical works preserved in the Islamic World for over a thousand years, Thomas Aquinas developed Scholasticism, which dominated the curricula of the new universities.[3] In England, King John signed the Magna Carta, beginning the tradition of Parliamentary advisement in England. This helped develop the principle of equality under law in European judisprudence.[4] The Southern Song dynasty began the century as a prosperous kingdom but were later invaded and annexed into the Yuan dynasty of the Mongols. The Kamakura Shogunate of Japan successfully resisted two Mongol invasion attempts in 1274 and 1281. The Korean state of Goryeo resisted a Mongol invasion, but eventually sued for peace and became a client state of the Yuan dynasty.[5] In North America, according to some population estimates, the population of Cahokia grew to be comparable to the population of 13th-century London.[6] In Peru, the Kingdom of Cuzco began as part of the Late Intermediate Period. In Mayan civilization, the 13th century marked the beginning of the Late Postclassic period. The Kanem Empire in what is now Chad reached its apex. The Solomonic dynasty in Ethiopia and the Zimbabwe Kingdom were founded. Eastern Hemisphere in 1200 AD Main article: 1200s 1202: Introduction of Liber Abaci by Fibonacci. 1202: Battle of Basian occurs on July 27, between Kingdom of Georgia and Seljuks. 1202: Battle of Mirebeau occurs on August 1, between Arthur I of Brittany and John of England. 1204: Islamization of Bengal by Bakhtiyar Khalji and oppression of Buddhism in East India. 1204: Fourth Crusade of 1202–1204 captures Zadar for Venice and sacks Byzantine Constantinople, creating the Latin Empire. 1204: Fall of Normandy from Angevin hands to the French King, Philip Augustus, end of Norman domination of France. 1205: The Battle of Adrianople occurred on April 14 between Bulgarians under Tsar Kaloyan of Bulgaria, and Crusaders under Baldwin I, (July 1172 – 1205), the first emperor of the Latin Empire of Constantinople. 1206: Genghis Khan is declared Great Khan of the Mongols. 1206: The Delhi Sultanate is established in Northern India under the Mamluk Dynasty. 1209: Francis of Assisi founds the Franciscan Order. 1209: The Albigensian Crusade is declared by Pope Innocent III. Main article: 1210s A page of the Italian Fibonacci's Liber Abaci from the Biblioteca Nazionale di Firenze showing the Fibonacci sequence with the position in the sequence labeled in Roman numerals and the value in Arabic-Hindu numerals. 1210: Qutb-ud-Din Aibak, the first ruler of the Delhi Sultanate, fell down from a horse while playing chovgan (a form of polo on horseback) in Lahore and died instantly when the pommel of the saddle pierced his ribs. 1212: The Battle of Las Navas de Tolosa in Iberia marks the beginning of a rapid Christian reconquest of the southern half of the Iberian Peninsula, mainly from 1230–1248, with the defeat of Moorish forces. 1212: Frederick of Sicily is crowned King of the Romans at Mainz. 1213: The Kingdom of France defeats the Crown of Aragon at the Battle of Muret. 1214: France defeats the English and Imperial German forces at the Battle of Bouvines. 1215: King John signs Magna Carta at Runnymede. 1216: Battle of Lipitsa between Russian principalities. 1216: Maravarman Sundara I reestablishes the Pandya Dynasty in Southern India 1217–1221: Fifth Crusade captures Egyptian Ayyubid port city of Damietta; ultimately the Crusaders withdraw. Main article: 1220s c. 1220: The Kingdom of Mapungubwe was established 1220: Frederick II, Holy Roman Emperor is crowned in Rome 1221: Merv, Herat, Bamyan and Nishapur are destroyed in the Mongol invasion of the Khwarazmian Empire. 1222: Andrew II of Hungary signs the Golden Bull which affirms the privileges of Hungarian nobility. 1223: The Signoria of the Republic of Venice is formed and consists of the Doge, the Minor Council, and the three leaders of the Quarantia. 1223: The Mongol Empire defeats various Russian principalities at the Battle of the Kalka River. 1223: Volga Bulgaria defeats the army of the Mongol Empire at the Battle of Samara Bend. 1225: Trần dynasty of Vietnam was established by Emperor Trần Thái Tông ascended to the throne after his uncle Trần Thủ Độ orchestrated the overthrow of the Lý dynasty. 1226–1250: Dispute between the so-called second Lombard League and Emperor Frederick II. 1227: Estonians are finally subjugated to German crusader rule during the Livonian Crusade. 1227: Genghis Khan dies. 1228–1229: Sixth Crusade under the excommunicated Emperor Frederick II, who returns Jerusalem to the Crusader States in a negotiated settlement with the Sultan of Egypt, Al-Kamil 1228–1230: First clash between Gregory IX and Emperor Frederick II. Main article: 1230s Portrait of the Chinese Zen Buddhist Wuzhun Shifan, painted in 1238, Song dynasty. 1231: Emperor Frederick II promulgates the Constitutions of Melfi, a far-reaching legal code influential in the development of continental European statehood.[7][8] 1232: The Mongols besiege Kaifeng, the capital of the Jin dynasty, capturing it in the following year. 1233: Battle of Ganter, Ken Arok defeated Kertajaya, the last king of Kediri, thus established Singhasari kingdom[9] Ken Arok ended the reign of Isyana Dynasty and started his own Rajasa dynasty. 1235: The Mandinka kingdoms unite to form the Mali Empire which leads to the downfall of Sosso in the 1230s. 1237: Emperor Frederick II virtually annihilates the forces of the second Lombard League at the Battle of Cortenuova. 1239–1250: Third conflict between the Holy Roman Empire and the Papacy. 1237–1240: Mongol Empire conquers Kievan Rus. 1238: Sukhothai becomes the first capital of Sukhothai Kingdom. Main article: 1240s 1240: Russians defeat the Swedish army at the Battle of the Neva. 1241: Mongol Empire defeats Hungary at the Battle of Mohi and defeats Poland at the Battle of Legnica. Hungary and Poland ravaged. 1242: Russians defeat the Teutonic Knights at the Battle of Lake Peipus. 1243–1250: Second Holy Roman Empire–Papacy War. 1244: Ayyubids and Khwarezmians defeat the Crusaders and their Muslim allies at the Battle of La Forbie. 1249: End of the Portuguese Reconquista against the Moors, when King Afonso III of Portugal reconquers the Algarve. 1248–1254: Seventh Crusade captures Egyptian Ayyubid port city of Damietta, crusaders ultimately withdraw, after the capture of French king Louis IX. Mamelukes overthrow Ayyubid Dynasty. Main article: 1250s Mongol Empire in 1227 at Genghis Khan's death By 1250, Pensacola culture, through trade, begins influencing Coastal Coles Creek culture.[10] 1250: The Mamluk dynasty is founded in Egypt. 1250: Death of Emperor Frederick II on December 13th. 1257: Baab Mashur Malamo established the Sultanate of Ternate in Maluku. 1258: Baghdad captured and destroyed by the Mongols, effective conclusion of the Abbasid Caliphate in Baghdad. 1258: Pandayan Emperor Jatavarman Sundara I invades Eastern India and northern Sri Lanka. 1259: Treaty of Paris is signed between Louis IX and Henry III Main article: 1260s 1260: Mongols first major war defeat in the Battle of Ain Jalut against the Egyptians. 1260: Toluid Civil War begins between Kublai Khan and Ariq Böke for the title of Great Khan. 1261: Byzantines under Michael VIII retake Constantinople from the Crusaders and Venice. 1262: Iceland brought under Norwegian rule, with the Old Covenant. 1265: Dominican theologian Thomas Aquinas begins to write his Summa Theologiae. 1268: Fall of the Crusader State of Antioch to the Egyptians. Main article: 1270s The opening page of one of Ibn al-Nafis' medical works. This is probably a copy made in India during the 17th or 18th century. 1270: Goryeo dynasty swears allegiance to the Yuan dynasty. 1270: The Zagwe dynasty is displaced by the Solomonic dynasty. 1271: Edward I of England and Charles of Anjou arrive in Acre, starting the Ninth Crusade against Baibars. 1272–1274: Second Council of Lyon attempts to unite the churches of the Eastern Roman Empire with the Church of Rome. 1274: The Mongols launch their first invasion of Japan, but they are repelled by the Samurai and the Kamikaze winds. 1274: The Tepanec give the Mexica permission to settle at the islet Cauhmixtitlan (Eagle's Place Between the Clouds) 1275: Sant Dnyaneshwar who wrote Dnyaneshwari (a commentary on the Bhagavad Gita) and Amrutanubhav was born. 1275: King Kertanegara of Singhasari launched Pamalayu expedition against Melayu Kingdom in Sumatra (ended in 1292). 1277: Passage of the last and most important of the Paris Condemnations by Bishop Tempier, which banned a number of Aristotelian propositions 1279: The Song dynasty ends after losing the Battle of Yamen to the Mongols. 1279: The Chola Dynasty in Southern India officially comes to an end. Main article: 1280s 1281: The Mongols launch their second invasion of Japan, but like their first invasion they are repelled by the Samurai and the Kamikaze winds. 1282: Aragon acquires Sicily after the Sicilian Vespers. 1284: Peterhouse, Cambridge founded by Hugo de Balsham, the Bishop of Ely. 1284: King Kertanegara launches the Pabali expedition to Bali, integrating Bali into the Singhasari territory. 1285: Second Mongol raid against Hungary, led by Nogai Khan. 1289: The County of Tripoli falls to the Bahri Mamluks led by Qalawun. 1289: Kertanegara insulted the envoy of Kublai Khan, who demanded that Java pay tribute to the Yuan Dynasty.[11][12] Main articles: 1290s and 1300s Hommage of Edward I (kneeling), to the Philippe le Bel (seated). As duke of Aquitaine, Edward was a vassal to the French king. The Mamluk Dynasty comes to an end and is replaced by the Khalji dynasty. 1290: By the Edict of Expulsion, King Edward I of England orders all Jews to leave the Kingdom of England. 1291: The Swiss Confederation of Uri, Schwyz, and Unterwalden forms. 1291: Mamluk Sultan of Egypt al-Ashraf Khalil captures Acre, thus ending the Crusader Kingdom of Jerusalem (the last Christian state remaining from the Crusades). 1292: Jayakatwang, duke of Kediri, rebels and kills Kertanegara, ending the Singhasari kingdom. 1292: Marco Polo, on his voyage from China to Persia, visits Sumatra and reports that, on the northern part of Sumatra, there were six trading ports, including Ferlec, Samudera and Lambri.[13] 1292: King Mangrai founds the Lanna kingdom. 1293: Mongol invasion of Java.[14] Kublai Khan of Yuan dynasty China, sends punitive attack against Kertanegara of Singhasari, who repels the Mongol forces. 1293: On 10 November, the coronation of Nararya Sangramawijaya as monarch, marks the foundation of the Hindu Majapahit kingdom in eastern Java. 1296: First War of Scottish Independence begins. 1297: Membership in the Mazor Consegio or the Great Council of Venice of the Venetian Republic is sealed and limited in the future to only those families whose names have been inscribed therein. 1299: Ottoman Empire is established under Osman I. 1300: Islam is likely established in the Aceh region. 1300: Aji Batara Agung Dewa Sakti founds the Kingdom of Kutai Kartanegara/Sultanate of Kutai in the Tepian Batu or Kutai Lama. 1300: The Turku Cathedral was consecrated in Turku.[15] 1300: Sri Rajahmura Lumaya, known in his shortened name Sri Lumay, a half-Tamil and half Malay minor prince of the Chola dynasty in Sumatra established the Indianized Rajahnate of Cebu in Cebu Island on the Philippine Archipelago. Alai Gate and Qutub Minar were built during the Mamluk and Khalji dynasties of the Delhi Sultanate.[16] Early 13th century – Xia Gui paints Twelve Views from a Thatched Hut, during the Southern Song dynasty (now in Nelson-Atkins Museum of Art, Kansas City, Missouri). The motet form originates out of the Ars antiqua tradition of Western European music. Manuscript culture develops out of this time period in cities in Europe, which denotes a shift from monasteries to cities for books. Pecia system of copying books develops in Italian university-towns and was taken up by the University of Paris in the middle of the century. Wooden movable type printing invented by Chinese governmental minister Wang Zhen in 1298. The earliest known rockets, landmines, and handguns are made by the Chinese for use in warfare. The Chinese adopt the windmill from the Islamic world. Guan ware vase is made, Southern Song dynasty. It is now kept at Percival David Foundation of Chinese Art, London. 1250 – Cliff Palace, Mesa Verde, and other Ancestral Pueblo architectural complexes reach their apex[17] 1280s – Eyeglasses are invented in Venice, Italy. Late 13th century – Night Attack on the Sanjo Palace is made during the Kamakura period. It is now kept at Museum of Fine Arts, Boston. Late 13th century – Descent of the Amida Trinity, raigo triptych, is made, Kamakura period. It is now kept at the Art Institute of Chicago. The Neo-Aramaic languages begin to develop during the course of the century. Christianity in the 13th century ^ "Samudra Pasai worthy to be world historical site". Republika Online. 2017-03-24. Retrieved 2020-01-24. ^ Coedès, George (1968). Walter F. Vella (ed.). The Indianized States of Southeast Asia. trans.Susan Brown Cowing. University of Hawaii Press. ISBN 978-0-8248-0368-1. ^ "St. Thomas Aquinas". Catholic Encyclopedia. Retrieved 2023-12-09. ^ Brooks, Christopher (2020). 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View (previous 50 | next 50) (20 | 50 | 100 | 250 | 500)Coin (links | edit) List of decades, centuries, and millennia (links | edit) Economy of Italy (links | edit) Imperialism (links | edit) Inca Empire (links | edit) Lavandula (links | edit) Levant (links | edit) Libro de los juegos (links | edit) History of Mali (links | edit) Romania (links | edit) Smelting (links | edit) 20th century (links | edit) 15th century (links | edit) 16th century (links | edit) 17th century (links | edit) 18th century (links | edit) 14th century (links | edit) 1st century (links | edit) 4th century (links | edit) 12th century (links | edit) 11th century (links | edit) 1282 (links | edit) 7th century (links | edit) 10th century (links | edit) 9th century (links | edit) 8th century (links | edit) 6th century (links | edit) 5th century (links | edit) 3rd century (links | edit) 2nd century (links | edit) 4th century BC (links | edit) 1st century BC (links | edit) 2nd century BC (links | edit) 3rd century BC (links | edit) 5th century BC (links | edit) 6th century BC (links | edit) 21st century BC (links | edit) 11th century BC (links | edit) 1299 (links | edit) 1326 (links | edit) 1359 (links | edit) 1389 (links | edit) 1154 (links | edit) 1163 (links | edit) 1160s (links | edit) 1380 (links | edit) 1141 (links | edit) 1135 (links | edit) 1204 (links | edit) 7th century BC (links | edit) View (previous 50 | next 50) (20 | 50 | 100 | 250 | 500) Retrieved from " WhatLinksHere/13th_century" Kids will have fun learning about our solar system with these free printable Solar System Worksheets for kids. 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Whether you are a parent, teacher, or homeschooler – these free science worksheets are a great way to make learning fun. You will love that they are no prep! Use these with an astronomy or solar system unit with pre k, kindergarten, first grade, 2nd grade, 3rd grade, 4th grade, 5th grade, and 6th grade children. Don't miss our solar system project ideas, free science lessons, and free 5th grade worksheets! Free solar system printables I created these solar system worksheets free as part of our Solar System unit. Studying the solar system is a lot of fun. Kids have a natural interest in the stars, sun, planets, and more and this science unit is a great way to draw on kids natural curiosity and interest for a teachable moment. They are a great way to help reinforce what kids are reading / learning as well to ensure they are remembering what they are studying as well. 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of the Solar System's mass is located within the Sun, and nearly 90% of the rest forms Jupiter and Saturn. There is a strong consensus among astronomers[e] that the Solar System has at least nine dwarf planets: Ceres, Orcus, Pluto, Haumea, Quaoar, Makemake, Gonggong, Eris, and Sedna. There are a vast number of small Solar System bodies, such as asteroids, comets, centaurs, meteoroids, and interplanetary dust clouds. Some of these bodies are in the asteroid belt (between Mars's and Jupiter's orbit) and the Kuiper belt (just outside Neptune's orbit).[f] Six planets, seven dwarf planets, and other bodies have orbiting natural satellites, which are commonly called 'moons'. The Solar System is constantly flooded by outflowing charged particles from the solar wind, forming the heliosphere. At around 75–90 astronomical units from the Sun,[g] the solar wind is halted, resulting in the heliopause. This is the boundary of the Solar System to interstellar space. The outermost region of the Solar System is the theorized Oort cloud, the source for long-period comets, extending to a radius of 2,000–200,000 AU. The closest star to the Solar System, Proxima Centauri, is 4.25 light-years (269,000 AU) away. Both stars belong to the Milky Way galaxy. Main article: Formation and evolution of the Solar System Diagram of the early Solar System's protoplanetary disk, out of which Earth and other Solar System bodies formed The Solar System formed at least 4.568 billion years ago from the gravitational collapse of a region within a large molecular cloud.[b] This initial cloud was likely several light-years across and probably birthed several stars.[14] As is typical of molecular clouds, this one consisted mostly of hydrogen, with some helium, and small amounts of heavier elements fused by previous generations of stars.[15] As the pre-solar nebula[15] collapsed, conservation of angular momentum caused it to rotate faster. The center, where most of the mass collected, became increasingly hotter than the surroundings.[14] As the contracting nebula spun faster, it began to flatten into a protoplanetary disc with a diameter of roughly 200 AU[14][16] and a hot, dense protostar at the center.[17][18] The planets formed by accretion from this disc,[19] in which dust and gas gravitationally attracted each other, coalescing to form ever larger bodies. Hundreds of protoplanets may have existed in the early Solar System, but they either merged or were destroyed or ejected, leaving the planets, dwarf planets, and leftover minor bodies.[20][21] Due to their higher boiling points, only metals and silicates could exist in solid form in the warm inner Solar System close to the Sun (within the frost line). They eventually formed the rocky planets of Mercury, Venus, Earth, and Mars. Because these refractory materials only comprised a small fraction of the solar nebula, the terrestrial planets could not grow very large.[20] The giant planets (Jupiter, Saturn, Uranus, and Neptune) formed further out, beyond the frost line, the point between the orbits of Mars and Jupiter where material is cool enough for volatile icy compounds to remain solid. The ices that formed these planets were more plentiful than the metals and silicates that formed the terrestrial inner planets, allowing them to grow massive enough to capture large atmospheres of hydrogen and helium, the lightest and most abundant elements.[20] Leftover debris that never became planets congregated in regions such as the asteroid belt, Kuiper belt, and Oort cloud.[20] Within 50 million years, the pressure and density of hydrogen in the center of the protostar became great enough for it to begin thermonuclear fusion.[22] As helium accumulates at its core, the Sun is growing brighter;[23] early in its main-sequence life its brightness was 70% that of what it is today.[24] The temperature, reaction rate, pressure, and density increased until hydrostatic equilibrium was achieved: the thermal pressure counterbalancing the force of gravity. At this point, the Sun became a main-sequence star.[25] Solar wind from the Sun created the heliosphere and swept away the remaining gas and dust from the protoplanetary disc into interstellar space.[23] Following the dissipation of the protoplanetary disk, the Nice model proposes that gravitational encounters between planetisimals and the gas giants caused each to migrate into different orbits. This led to dynamical instability of the entire system, which scattered the planetisimals and ultimately placed the gas giants in their current positions. During this period, the grand tack hypothesis suggests that a final inward migration of Jupiter dispersed much of the asteroid belt, leading to the Late Heavy Bombardment of the inner planets.[26][27] The Solar System remains in a relatively stable, slowly evolving state by following isolated, gravitationally bound orbits around the Sun.[28] Although the Solar System has been fairly stable for billions of years, it is technically chaotic, and may eventually be disrupted. There is a small chance that another star will pass through the Solar System in the next few billion years. Although this could destabilize the system and eventually lead millions of years later to expulsion of planets, collisions of planets, or planets hitting the Sun, it would most likely leave the Solar System much as it is today.[29] The current Sun compared to its peak size in the red-giant phase The Sun's main-sequence phase, from beginning to end, will last about 10 billion years for the Sun compared to around two billion years for all other subsequent phases of the Sun's pre-remnant life combined.[30] The Solar System will remain roughly as it is known today until the hydrogen in the core of the Sun has been entirely converted to helium, which will occur roughly 5 billion years from now. This will mark the end of the Sun's main-sequence life. At that time, the core of the Sun will contract with hydrogen fusion occurring along a shell surrounding the inert helium, and the energy output will be greater than at present. The outer layers of the Sun will expand to roughly 260 times its current diameter, and the Sun will become a red giant. Because of its increased surface area, the surface of the Sun will be cooler (2,600 K (4,220 °F) at its coolest) than it is on the main sequence.[30] The expanding Sun is expected to vaporize Mercury as well as Venus, and render Earth and Mars uninhabitable (possibly destroying Earth as well).[31][32] Eventually, the core will be hot enough for helium fusion; the Sun will burn helium for a fraction of the time it burned hydrogen in the core. The Sun is not massive enough to commence the fusion of heavier elements, and nuclear reactions in the core will dwindle. Its outer layers will be ejected into space, leaving behind a dense white dwarf, half the original mass of the Sun but only the size of Earth.[30] The ejected outer layers may form a planetary nebula, returning some of the material that formed the Sun—but now enriched with heavier elements like carbon—to the interstellar medium.[33][34] Astronomers sometimes divide the Solar System structure into separate regions. The inner Solar System includes Mercury, Venus, Earth, Mars, and the bodies in the asteroid belt. The outer Solar System includes Jupiter, Saturn, Uranus, Neptune, and the bodies in the Kuiper belt.[35] Since the discovery of the Kuiper belt, the outermost parts of the Solar System are considered a distinct region consisting of the objects beyond Neptune.[36] Further information: List of Solar System objects and List of interstellar and circumstellar molecules The principal component of the Solar System is the Sun, a G-type main-sequence star that contains 99.86% of the system's known mass and dominates it gravitationally.[37] The Sun's four largest orbiting bodies, the giant planets, account for 99% of the remaining mass, with Jupiter and Saturn together comprising more than 90%. The remaining objects of the Solar System (including the four terrestrial planets, the dwarf planets, moons, asteroids, and comets) together comprise less than 0.002% of the Solar System's total mass.[h] The Sun is composed of roughly 98% hydrogen and helium,[41] as are Jupiter and Saturn.[42][43] A composition gradient exists in the Solar System, created by heat and light pressure from the early Sun; those objects closer to the Sun, which are more affected by heat and light pressure, are composed of elements with high melting points. Objects farther from the Sun are composed largely of materials with lower melting points.[44] The boundary in the Solar System beyond which those volatile substances could coalesce is known as the frost line, and it lies at roughly five times the Earth's distance from the Sun.[5] Animations of the Solar System's inner planets orbiting. Each frame represents 2 days of motion. Animations of the Solar System's outer planets orbiting. This animation is 100 times faster than the inner planet animation. The planets and other large objects in orbit around the Sun lie near the plane of Earth's orbit, known as the ecliptic. Smaller icy objects such as comets frequently orbit at significantly greater angles to this plane.[45][46] Most of the planets in the Solar System have secondary systems of their own, being orbited by natural satellites called moons. All of the largest natural satellites are in synchronous rotation, with one face permanently turned toward their parent. The four giant planets have planetary rings, thin discs of tiny particles that orbit them in unison.[47] As a result of the formation of the Solar System, planets and most other objects orbit the Sun in the same direction that the Sun is rotating. That is, counter-clockwise, as viewed from above Earth's north pole.[48] There are exceptions, such as Halley's Comet.[49] Most of the larger moons orbit their planets in prograde direction, matching the direction of planetary rotation; Neptune's moon Triton is the largest to orbit in the opposite, retrograde manner.[50] Most larger objects rotate around their own axes in the prograde direction relative to their orbit, though the rotation of Venus is retrograde.[51] To a good first approximation, Kepler's laws of planetary motion describe the orbits of objects around the Sun.[52]:433–437 These laws stipulate that each object travels along an ellipse with the Sun at one focus, which causes the body's distance from the Sun to vary over the course of its year. A body's closest approach to the Sun is called its perihelion, whereas its most distant point from the Sun is called its aphelion.[53]:9-6 With the exception of Mercury, the orbits of the planets are nearly circular, but many comets, asteroids, and Kuiper belt objects follow highly elliptical orbits. Kepler's laws only account for the influence of the Sun's gravity upon an orbiting body, not the gravitational pulls of different bodies upon each other. On a human time scale, these perturbations can be accounted for using numerical models,[53]:9-6 but the planetary system can change chaotically over billions of years.[54] The angular momentum of the Solar System is a measure of the total amount of orbital and rotational momentum possessed by all its moving components.[55] Although the Sun dominates the system by mass, it accounts for only about 2% of the angular momentum.[56][57] The planets, dominated by Jupiter, account for most of the rest of the angular momentum due to the combination of their mass, orbit, and distance from the Sun, with a possibly significant contribution from comets.[56] Comparison of the distances between planets, with the white bar showing orbital variations. The size of the planets is not to scale. Relative orbital distances in the Solar System visualized as a condensed rectangle The radius of the Sun is 0.0047 AU (700,000 km; 400,000 mi).[58] Thus, the Sun occupies 0.00001% (1 part in 107) of the volume of a sphere with a radius the size of Earth's orbit, whereas Earth's volume is roughly 1 millionth (10−6) that of the Sun. Jupiter, the largest planet, is 5.2 AU from the Sun and has a radius of 71,000 km (0.00047 AU; 44,000 mi), whereas the most distant planet, Neptune, is 30 AU from the Sun.[43][59] With a few exceptions, the farther a planet or belt is from the Sun, the larger the distance between its orbit and the orbit of the next nearest object to the Sun. For example, Venus is approximately 0.33 AU farther out from the Sun than Mercury, whereas Saturn is 4.3 AU out from Jupiter, and Neptune lies 10.5 AU out from Uranus. Attempts have been made to determine a relationship between these orbital distances, like the Titius–Bode law[60] and Johannes Kepler's model based on the Platonic solids,[61] but ongoing discoveries have invalidated these hypotheses.[62] Some Solar System models attempt to convey the relative scales involved in the Solar System in human terms. Some are small in scale (and may be mechanical—called orreries)—whereas others extend across cities or regional areas.[63] The largest such scale model, the Sweden Solar System, uses the 110-meter (361-foot) Avicii Arena in Stockholm as its substitute Sun, and, following the scale, Jupiter is a 7.5-meter (25-foot) sphere at Stockholm Arlanda Airport, 40 km (25 mi) away, whereas the farthest current object, Sedna, is a 10 cm (4 in) sphere in Luleå, 912 km (567 mi) away.[64][65] At that scale, the distance to Proxima Centauri would be roughly 8 times further than the Moon is from Earth. If the Sun–Neptune distance is scaled to 100 metres (330 ft), then the Sun would be about 3 cm (1.2 in) in diameter (roughly two-thirds the diameter of a golf ball), the giant planets would be all smaller than about 3 mm (0.12 in), and Earth's diameter along with that of the other terrestrial planets would be smaller than a flea (0.3 mm or 0.012 in) at this scale.[66] Main article: Planetary habitability in the Solar System Comparison of the habitable zones of the Solar System and TRAPPIST-1, an ultracool red dwarf star known to have seven terrestrial planets in stable orbits around the star.Comparison of the habitable zones for different stellar temperatures, with a sample of known exoplanets plus the Earth, Mars, and Venus. From top to bottom are an F-type main-sequence star, a yellow dwarf (G-type main-sequence star), an orange dwarf (K-type main-sequence star), a typical red dwarf, and an ultra-cool dwarf. Besides solar energy, the primary characteristic of the Solar System enabling the presence of life is the heliosphere and planetary magnetic fields (for those planets that have them). These magnetic fields partially shield the Solar System from high-energy interstellar particles called cosmic rays. The density of cosmic rays in the interstellar medium and the strength of the Sun's magnetic field change on very long timescales, so the level of cosmic-ray penetration in the Solar System varies, though by how much is unknown.[67] The zone of habitability of the Solar System is conventionally located in the inner Solar System, where planetary surface or atmospheric temperatures admit the possibility of liquid water.[68] Habitability might be possible in subsurface oceans of various outer Solar System moons.[69] Compared to many extrasolar systems, the Solar System stands out in lacking planets interior to the orbit of Mercury.[70][71] The known Solar System lacks super-Earths, planets between one and ten times as massive as the Earth,[70] although the hypothetical Planet Nine, if it does exist, could be a super-Earth orbiting in the edge of the Solar System.[72] Uncommonly, it has only small terrestrial and large gas giants; elsewhere planets of intermediate size are typical—both rocky and gas—so there is no "gap" as seen between the size of Earth and of Neptune (with a radius 3.8 times as large). As many of these super-Earths are closer to their respective stars than Mercury is to the Sun, a hypothesis has arisen that all planetary systems start with many close-in planets, and that typically a sequence of their collisions causes consolidation of mass into few larger planets, but in case of the Solar System the collisions caused their destruction and ejection.[70][73] The orbits of Solar System planets are nearly circular. Compared to many other systems, they have smaller orbital eccentricity.[70] Although there are attempts to explain it partly with a bias in the radial-velocity detection method and partly with long interactions of a quite high number of planets, the exact causes remain undetermined.[70][74] Main article: Sun The Sun in true white color The Sun is the Solar System's star and by far its most massive component. Its large mass (332,900 Earth masses),[75] which comprises 99.86% of all the mass in the Solar System,[76] produces temperatures and densities in its core high enough to sustain nuclear fusion of hydrogen into helium.[77] This releases an enormous amount of energy, mostly radiated into space as electromagnetic radiation peaking in visible light.[78][79] Because the Sun fuses hydrogen at its core, it is a main-sequence star. More specifically, it is a G2-type main-sequence star, where the type designation refers to its effective temperature. Hotter main-sequence stars are more luminous but shorter lived. The Sun's temperature is intermediate between that of the hottest stars and that of the coolest stars. Stars brighter and hotter than the Sun are rare, whereas substantially dimmer and cooler stars, known as red dwarfs, make up about 75% of the fusor stars in the Milky Way.[80] The Sun is a population I star, having formed in the spiral arms of the Milky Way galaxy. It has a higher abundance of elements heavier than hydrogen and helium ("metals" in astronomical parlance) than the older population II stars in the galactic bulge and halo.[81] Elements heavier than hydrogen and helium were formed in the cores of ancient and exploding stars, so the first generation of stars had to die before the universe could be enriched with these atoms. The oldest stars contain few metals, whereas stars born later have more. This higher metallicity is thought to have been crucial to the Sun's development of a planetary system because the planets formed from the accretion of "metals".[82] The region of space dominated by the Solar magnetosphere is the heliosphere, which spans much of the Solar System. Along with light, the Sun radiates a continuous stream of charged particles (a plasma) called the solar wind. This stream spreads outwards at speeds from 900,000 kilometres per hour (560,000 mph) to 2,880,000 kilometres per hour (1,790,000 mph),[83] filling the vacuum between the bodies of the Solar System. The result is a thin, dusty atmosphere, called the interplanetary medium, which extends to at least 100 AU.[84] Activity on the Sun's surface, such as solar flares and coronal mass ejections, disturbs the heliosphere, creating space weather and causing geomagnetic storms. [85] Coronal mass ejections and similar events blow a magnetic field and huge quantities of material from the surface of the Sun. The interaction of this magnetic field and material with Earth's magnetic field funnels charged particles into Earth's upper atmosphere, where its interactions create aurorae seen near the magnetic poles.[86] The largest stable structure within the heliosphere is the heliospheric current sheet, a spiral form created by the actions of the Sun's rotating magnetic field on the interplanetary medium.[87][88] The inner Solar System is the region comprising the terrestrial planets and the asteroids.[89] Composed mainly of silicates and metals,[90] the objects of the inner Solar System are relatively close to the Sun; the radius of this entire region is less than the distance between the orbits of Jupiter and Saturn. This region is within the frost line, which is a little less than 5 AU from the Sun.[45] Main article: Terrestrial planet The four terrestrial planets Mercury, Venus, Earth and Mars The four terrestrial or inner planets have dense, rocky compositions, few or no moons, and no ring systems. They are composed largely of refractory minerals such as silicates—which form their crusts and mantles—and metals such as iron and nickel which form their cores. Three of the four inner planets (Venus, Earth, and Mars) have atmospheres substantial enough to generate weather; all have impact craters and tectonic surface features, such as rift valleys and volcanoes.[91] Mercury (0.31–0.59 AU from the Sun)[D 6] is the smallest planet in the Solar System. Its surface is grayish, with an expansive rupes (cliff) system generated from thrust faults and bright ray systems formed by impact event remnants.[92] The surface has widely varying temperature, with the equatorial regions ranging from −170 °C (−270 °F) at night to 420 °C (790 °F) during sunlight. In the past, Mercury was volcanically active, producing smooth basaltic plains similar to the Moon.[93] It is likely that Mercury has a silicate crust and a large iron core.[94][95] Mercury has a very tenuous atmosphere, consisting of solar-wind particles and ejected atoms.[96] Mercury has no natural satellites.[97] Venus (0.72–0.73 AU)[D 6] has a reflective, whitish atmosphere that is mainly composed of carbon dioxide. At the surface, the atmospheric pressure is ninety times as dense as on Earth's sea level.[98] Venus has a surface temperatures over 400 °C (752 °F), mainly due to the amount of greenhouse gases in the atmosphere.[99] The planet lacks a protective magnetic field to protect against stripping by the solar wind, which suggests that its atmosphere is sustained by volcanic activity.[100] Its surface displays extensive evidence of volcanic activity with stagnant lid tectonics.[101] Venus has no natural satellites.[97] Earth (0.98–1.02 AU)[D 6] is the only place in the universe where life and surface liquid water are known to exist.[102] Earth's atmosphere contains 78% nitrogen and 21% oxygen, which is the result of the presence of life.[103][104] The planet has a complex climate and weather system, with conditions differing drastically between climate regions.[105] The solid surface of Earth is dominated by green vegetation, deserts and white ice sheets.[106][107][108] Earth's surface is shaped by plate tectonics that formed the continental masses.[93] Earth's planetary magnetosphere shields the surface from radiation, limiting atmospheric stripping and maintaining life habitability.[109] The Moon is Earth's only natural satellite.[110] Its diameter is one-quarter the size of Earth's.[111] Its surface is covered in very fine regolith and dominated by impact craters.[112][113] Large dark patches on the Moon, maria, are formed from past volcanic activity.[114] The Moon's atmosphere is extremely thin, consisting of a partial vacuum with particle densities of under 107 per cm−3.[115] Mars (1.38–1.67 AU)[D 6] has a radius about half of that of Earth.[116] Most of the planet is red due to iron oxide in Martian soil,[117] and the polar regions are covered in white ice caps made of water and carbon dioxide.[118] Mars has an atmosphere composed mostly of carbon dioxide, with surface pressure 0.6% of that of Earth, which is sufficient to support some weather phenomena.[119] During the Mars year (687 Earth days), there are large surface temperature swings on the surface between −78.5 °C (−109.3 °F) to 5.7 °C (42.3 °F). The surface is peppered with volcanoes and rift valleys, and has a rich collection of minerals.[120][121] Mars has a highly differentiated internal structure, and lost its magnetosphere 4 billion years ago.[122][123] Mars has two tiny moons:[124] Phobos is Mars's inner moon. It is a small, irregularly shaped object with a mean radius of 11 km (7 mi). Its surface is very unreflective and dominated by impact craters.[D 7][125] In particular, Phobos's surface has a very large Stickney impact crater that is roughly 4.5 km (2.8 mi) in radius.[126] Deimos is Mars's outer moon. Like Phobos, it is irregularly shaped, with a mean radius of 6 km (4 mi) and its surface reflects little light.[D 8][D 9] However, the surface of Deimos is noticeably smoother than Phobos because the regolith partially covers the impact craters.[127] Main article: Asteroid Overview of the inner Solar System up to Jupiter's orbitAsteroids, except for the largest, Ceres, are classified as small Solar System bodies and are composed mainly of carbonaceous, refractory rocky and metallic minerals, with some ice.[128][129] They range from a few meters to hundreds of kilometers in size. Many asteroids are divided into asteroid groups and families based on their orbital characteristics. Some asteroids have natural satellites that orbit them, that is, asteroids that orbit larger asteroids.[130] Mercury-crossing asteroids are those with perihelia within the orbit of Mercury. At least 362 are known to date, and include the closest objects to the Sun known in the Solar System.[131] No vulcanoids, asteroids between the orbit of Mercury and the Sun, have been discovered.[132][133] As of 2024, one asteroid has been discovered to orbit completely within Venus's orbit, 594913 'Ayló'chaxnim.[134] Venus-crossing asteroids are those that cross the orbit of Venus. There are 2,809 as of 2015.[135] Near-Earth asteroids have orbits that approach relatively close to Earth's orbit,[136] and some of them are potentially hazardous objects because they might collide with Earth in the future.[137][138] There are over 37,000 known as of 2024.[139] A number of solar-orbiting meteoroids were large enough to be tracked in space before striking Earth. It is now widely accepted that collisions in the past have had a significant role in shaping the geological and biological history of Earth.[140] Mars-crossing asteroids are those with perihelia above 1.3 AU which cross the orbit of Mars.[141] As of 2024, NASA lists 26,182 confirmed Mars-crossing asteroids.[135] The asteroid belt occupies a torus-shaped region between 2.3 and 3.3 AU from the Sun, which lies between the orbits of Mars and Jupiter. It is thought to be remnants from the Solar System's formation that failed to coalesce because of the gravitational interference of Jupiter.[142] The asteroid belt contains tens of thousands, possibly millions, of objects over one kilometer in diameter.[143] Despite this, the total mass of the asteroid belt is unlikely to be more than a thousandth of that of Earth.[40] The asteroid belt is very sparsely populated; spacecraft routinely pass through without incident.[144] The four largest asteroids: Ceres, Vesta, Pallas, Hygiea. Only Ceres and Vesta have been visited by a spacecraft and thus have a detailed picture. Below are the descriptions of the three largest bodies in the asteroid belt. They are all considered to be relatively intact protoplanets, a precursor stage before becoming a fully-formed planet (see List of exceptional asteroids):[145][146][147] Ceres (2.55–2.98 AU) is the only dwarf planet in the asteroid belt.[148] It is the largest object in the belt, with a diameter of 940 km (580 mi).[149] Its surface contains a mixture of carbon,[150] frozen water and hydrated minerals.[151] There are signs of past cryovolcanic activity, where volatile material such as water are erupted onto the surface, as seen in surface bright spots.[152] Ceres has a very thin water vapor atmosphere, but practically speaking it is indistinguishable from a vacuum.[153] Vesta (2.13–3.41 AU) is the second-largest object in the asteroid belt.[154] Its fragments survive as the Vesta asteroid family[155] and numerous HED meteorites found on Earth.[156] Vesta's surface, dominated by basaltic and metamorphic material, has a denser composition than Ceres's.[157] Its surface is marked by two giant craters: Rheasilvia and Veneneia.[158] Pallas (2.15–2.57 AU) is the third-largest object in the asteroid belt.[154] It has its own Pallas asteroid family.[155] Not much is known about Pallas because it has never been visited by a spacecraft,[159] though its surface is predicted to be composed of silicates.[160] Hilda asteroids are in a 3:2 resonance with Jupiter; that is, they go around the Sun three times for every two Jovian orbits.[161] They lie in three linked clusters between Jupiter and the main asteroid belt. Trojans are bodies located within another body's gravitationally stable Lagrange points: L4, 60° ahead in its orbit, or L5, 60° behind in its orbit.[162] Every planet except Mercury and Saturn is known to possess at least 1 trojan.[163][164][165] The Jupiter trojan population is roughly equal to that of the asteroid belt.[166] After Jupiter, Neptune possesses the most confirmed trojans, at 28.[167] The outer region of the Solar System is home to the giant planets and their large moons. The centaurs and many short-period comets orbit in this region. Due to their greater distance from the Sun, the solid objects in the outer Solar System contain a higher proportion of volatiles such as water, ammonia, and methane, than planets of the inner Solar System because their lower temperatures allow these compounds to remain solid, without significant sublimation.[20] Main article: Giant planet The outer planets Jupiter, Saturn, Uranus and Neptune, compared to the inner planets Earth, Venus, Mars, and Mercury at the bottom right The four outer planets, called giant planets or Jovian planets, collectively make up 99% of the mass orbiting the Sun.[h] All four giant planets have multiple moons and a ring system, although only Saturn's rings are easily observed from Earth.[91] Jupiter and Saturn are composed mainly of gases with extremely low melting points, such as hydrogen, helium, and neon,[168] hence their designation as gas giants.[169] Uranus and Neptune are ice giants,[170] meaning they are largely composed of 'ice' in the astronomical sense (chemical compounds with melting points of up to a few hundred kelvins[168] such as water, methane, ammonia, hydrogen sulfide, and carbon dioxide.[171]) Icy substances comprise the majority of the satellites of the giant planets and small objects that lie beyond Neptune's orbit.[171][172] Jupiter (4.95–5.46 AU)[D 6] is the biggest and most massive planet in the Solar System. On its surface, there are orange-brown and white cloud bands moving via the principles of atmospheric circulation, with giant storms swirling on the surface such as the Great Red Spot and white 'ovals'. Jupiter possesses a strong enough magnetosphere to redirect ionizing radiation and cause auroras on its poles.[173] As of 2025, Jupiter has 97 confirmed satellites, which can roughly be sorted into three groups: The Amalthea group, consisting of Metis, Adrastea, Amalthea, and Thebe. They orbit substantially closer to Jupiter than other satellites.[174] Materials from these natural satellites are the source of Jupiter's faint ring.[175] The Galilean moons, consisting of Ganymede, Callisto, Io, and Europa. They are the largest moons of Jupiter and exhibit planetary properties.[176] Irregular satellites, consisting of substantially smaller natural satellites. They have more distant orbits than the other objects.[177] Saturn (9.08–10.12 AU)[D 6] has a distinctive visible ring system orbiting around its equator composed of small ice and rock particles. Like Jupiter, it is mostly made of hydrogen and helium.[178] At its north and south poles, Saturn has peculiar hexagon-shaped storms larger than the diameter of Earth. Saturn has a magnetosphere capable of producing weak auroras. As of 2025, Saturn has 274 confirmed satellites, grouped into: Ring moonlets and shepherds, which orbit inside or close to Saturn's rings. A moonlet can only partially clear out dust in its orbit,[179] while the ring shepherds are able to completely clear out dust, forming visible gaps in the rings.[180] Inner large satellites Mimas, Enceladus, Tethys, and Dione. These satellites orbit within Saturn's E ring. They are composed mostly of water ice and are believed to have differentiated internal structures.[181] Trojan moons Calypso and Telesto (trojans of Tethys), and Helene and Polydeuces (trojans of Dione). These small moons share their orbits with Tethys and Dione, leading or trailing either.[182][183] Outer large satellites Rhea, Titan, Hyperion, and Iapetus.[181] Titan is the only satellite in the Solar System to have a substantial atmosphere.[184] Irregular satellites, consisting of substantially smaller natural satellites. They have more distant orbits than the other objects. Phoebe is the largest irregular satellite of Saturn.[185] Uranus (18.3–20.1 AU),[D 6] uniquely among the planets, orbits the Sun on its side with an axial tilt >90°. This gives the planet extreme seasonal variation as each pole points alternately toward and then away from the Sun.[186] Uranus's outer layer has a muted cyan color, but underneath these clouds are many mysteries about its climate, such as unusually low internal heat and erratic cloud formation. As of 2025, Uranus has 28 confirmed satellites, divided into three groups: Inner satellites, which orbit inside Uranus's ring system.[187] They are very close to each other, which suggests that their orbits are chaotic.[188] Large satellites, consisting of Titania, Oberon, Umbriel, Ariel, and Miranda.[189] Most of them have roughly equal amounts of rock and ice, except Miranda, which is made primarily of ice.[190] Irregular satellites, having more distant and eccentric orbits than the other objects.[191] Neptune (29.9–30.5 AU)[D 6] is the furthest planet known in the Solar System. Its outer atmosphere has a slightly muted cyan color, with occasional storms on the surface that look like dark spots. Like Uranus, many atmospheric phenomena of Neptune are unexplained, such as the thermosphere's abnormally high temperature or the strong tilt (47°) of its magnetosphere. As of 2025, Neptune has 16 confirmed satellites, divided into two groups: Regular satellites, which have circular orbits that lie near Neptune's equator.[185] Irregular satellites, which as the name implies, have less regular orbits. One of them, Triton, is Neptune's largest moon. It is geologically active, with erupting geysers of nitrogen gas, and possesses a thin, cloudy nitrogen atmosphere.[192][184] Main article: Centaur The centaurs are icy, comet-like bodies whose semi-major axes are longer than Jupiter's and shorter than Neptune's (between 5.5 and 30 AU). These are former Kuiper belt and scattered disc objects (SDOs) that were gravitationally perturbed closer to the Sun by the outer planets, and are expected to become comets or be ejected out of the Solar System.[39] While most centaurs are inactive and asteroid-like, some exhibit cometary activity, such as the first centaur discovered, 2060 Chiron, which has been classified as a comet (95P) because it develops a coma just as comets do when they approach the Sun.[193] The largest known centaur, 10199 Chariklo, has a diameter of about 250 km (160 mi) and is one of the few minor planets possessing a ring system.[194][195] Beyond the orbit of Neptune lies the area of the "trans-Neptunian region", with the doughnut-shaped Kuiper belt, home of Pluto and several other dwarf planets, and an overlapping disc of scattered objects, which is tilted toward the plane of the Solar System and reaches much further out than the Kuiper belt. The entire region is still largely unexplored. It appears to consist overwhelmingly of many thousands of small worlds—the largest having a diameter only a fifth that of Earth and a mass far smaller than that of the Moon—composed mainly of rock and ice. This region is sometimes described as the "third zone of the Solar System", enclosing the inner and the outer Solar System.[196] Main article: Kuiper belt Plot of objects around the Kuiper belt and other asteroid populations. J, S, U and N denotes Jupiter, Saturn, Uranus and Neptune. Orbit classification of Kuiper belt objects. Some clusters that is subjected to orbital resonance are marked. The Kuiper belt is a great ring of debris similar to the asteroid belt, but consisting mainly of objects composed primarily of ice.[197] It extends between 30 and 50 AU from the Sun. It is composed mainly of small Solar System bodies, although the largest few are probably large enough to be dwarf planets.[198] There are estimated to be over 100,000 Kuiper belt objects with a diameter greater than 50 km (30 mi), but the total mass of the Kuiper belt is thought to be only a tenth or even a hundredth the mass of Earth.[39] Many Kuiper belt objects have satellites,[199] and most have orbits that are substantially inclined (~10°) to the plane of the ecliptic.[200] The Kuiper belt can be roughly divided into the "classical" belt and the resonant trans-Neptunian objects.[197] The latter have orbits whose periods are in a simple ratio to that of Neptune: for example, going around the Sun twice for every three times that Neptune does, or once for every two. The classical belt consists of objects having no resonance with Neptune, and extends from roughly 39.4 to 47.7 AU.[201] Members of the classical Kuiper belt are sometimes called "cubewanos", after the first of their kind to be discovered, originally designated 1992 QB1, (and has since been named Albion); they are still in near primordial, low-eccentricity orbits.[202] There is strong consensus among astronomers that five members of the Kuiper belt are dwarf planets.[198][203] Many dwarf planet candidates are being considered, pending further data for verification.[204] Pluto (29.7–49.3 AU) is the largest known object in the Kuiper belt. Pluto has a relatively eccentric orbit, inclined 17 degrees to the ecliptic plane. Pluto has a 2:3 resonance with Neptune, meaning that Pluto orbits twice around the Sun for every three Neptunian orbits. Kuiper belt objects whose orbits share this resonance are called plutinos.[205] Pluto has five moons: Charon, Styx, Nix, Kerberos, and Hydra.[206] Charon, the largest of Pluto's moons, is sometimes described as part of a binary system with Pluto, as the two bodies orbit a barycenter of gravity above their surfaces (i.e. they appear to "orbit each other"). Orcus (30.3–48.1 AU), is in the same 2:3 orbital resonance with Neptune as Pluto, and is the largest such object after Pluto itself.[207] Its eccentricity and inclination are similar to Pluto's, but its perihelion lies about 120° from that of Pluto. Thus, the phase of Orcus's orbit is opposite to Pluto's: Orcus is at aphelion (most recently in 2019) around when Pluto is at perihelion (most recently in 1989) and vice versa.[208] For this reason, it has been called the anti-Pluto.[209][210] It has one known moon, Vanth.[211] Haumea (34.6–51.6 AU) was discovered in 2005.[212] It is in a temporary 7:12 orbital resonance with Neptune.[207] Haumea possesses a ring system, two known moons named Hiʻiaka and Namaka, and rotates so quickly (once every 3.9 hours) that it is stretched into an ellipsoid. It is part of a collisional family of Kuiper belt objects that share similar orbits, which suggests a giant impact on Haumea ejected fragments into space billions of years ago.[213] Makemake (38.1–52.8 AU), although smaller than Pluto, is the largest known object in the classical Kuiper belt (that is, a Kuiper belt object not in a confirmed resonance with Neptune). Makemake is the brightest object in the Kuiper belt after Pluto. Discovered in 2005, it was officially named in 2009.[214] Its orbit is far more inclined than Pluto's, at 29°.[215] It has one known moon, S/2015 (136472) 1.[216] Quaoar (41.9–45.5 AU) is the second-largest known object in the classical Kuiper belt, after Makemake. Its orbit is significantly less eccentric and inclined than those of Makemake or Haumea.[207] It possesses a ring system and one known moon, Weywot.[217] Main article: Scattered disc The orbital eccentricities and inclinations of the scattered disc population compared to the classical and resonant Kuiper belt objects The scattered disc, which overlaps the Kuiper belt but extends out to near 500 AU, is thought to be the source of short-period comets. Scattered-disc objects are believed to have been perturbed into erratic orbits by the gravitational influence of Neptune's early outward migration. Most scattered disc objects have perihelia within the Kuiper belt but aphelia far beyond it (some more than 150 AU from the Sun). SDOs' orbits can be inclined up to 46.8° from the ecliptic plane.[218] Some astronomers consider the scattered disc to be merely another region of the Kuiper belt and describe scattered-disc objects as "scattered Kuiper belt objects".[219] Some astronomers classify centaurs as inward-scattered Kuiper belt objects along with the outward-scattered residents of the scattered disc.[220] Currently, there is strong consensus among astronomers that two of the bodies in the scattered disc are dwarf planets: Eris (38.3–97.5 AU) is the largest known scattered disc object and the most massive known dwarf planet. Eris's discovery contributed to a debate about the definition of a planet because it is 25% more massive than Pluto[221] and about the same diameter. It has one known moon, Dysnomia. Like Pluto, its orbit is highly eccentric, with a perihelion of 38.2 AU (roughly Pluto's distance from the Sun) and an aphelion of 97.6 AU, and steeply inclined to the ecliptic plane at an angle of 44°.[222] Gonggong (33.8–101.2 AU) is a dwarf planet in a comparable orbit to Eris, except that it is in a 3:10 resonance with Neptune.[D 10] It has one known moon, Xiangliu.[223] Main article: Extreme trans-Neptunian object The current orbits of Sedna, 2012 VP113, Leleākūhonua (pink), and other very distant objects (red, brown and cyan) along with the predicted orbit of the hypothetical Planet Nine (dark blue) Some objects in the Solar System have a very large orbit, and therefore are much less affected by the known giant planets than other minor planet populations. These bodies are called extreme trans-Neptunian objects, or ETNOs for short.[224] Generally, ETNOs' semi-major axes are at least 150–250 AU wide.[224][225] For example, 541132 Leleākūhonua orbits the Sun once every ~32,000 years, with a distance of 65–2000 AU from the Sun.[D 11] This population is divided into three subgroups by astronomers. The scattered ETNOs have perihelia around 38–45 AU and an exceptionally high eccentricity of more than 0.85. As with the regular scattered disc objects, they were likely formed as result of gravitational scattering by Neptune and still interact with the giant planets. The detached ETNOs, with perihelia approximately between 40–45 and 50–60 AU, are less affected by Neptune than the scattered ETNOs, but are still relatively close to Neptune. The sednoids or inner Oort cloud objects, with perihelia beyond 50–60 AU, are too far from Neptune to be strongly influenced by it.[224] Currently, there is one ETNO that is classified as a dwarf planet: Sedna (76.2–937 AU) was the first extreme trans-Neptunian object to be discovered. It is a large, reddish object, and takes ~11,400 years to complete one orbit. Mike Brown, who discovered the object in 2003, asserts that it cannot be part of the scattered disc or the Kuiper belt because its perihelion is too distant to have been affected by Neptune's migration.[226] The sednoid population is named after Sedna.[224] Diagram of the Sun's magnetosphere and helioshealth The Sun's stellar-wind bubble, the heliosphere, a region of space dominated by the Sun, has its boundary at the termination shock. Based on the Sun's peculiar motion relative to the local standard of rest, this boundary is roughly 80–100 AU from the Sun upwind of the interstellar medium and roughly 200 AU from the Sun downwind.[227] Here the solar wind collides with the interstellar medium[228] and dramatically slows, condenses and becomes more turbulent, forming a great oval structure known as the helioshеath.[227] The helioshеath has been theorized to look and behave very much like a comet's tail, extending outward for a further 40 AU on the upwind side but tailing many times that distance downwind to possibly several thousands of AU.[229][230] Evidence from the Cassini and Interstellar Boundary Explorer spacecraft has suggested that it is forced into a bubble shape by the constraining action of the interstellar magnetic field,[231][232] but the actual shape remains unknown.[233] The shape and form of the outer edge of the heliosphere is likely affected by the fluid dynamics of interactions with the interstellar medium as well as solar magnetic fields prevailing to the south, e.g. it is bluntly shaped with the northern hemisphere extending 9 AU farther than the southern hemisphere.[227] The heliopause is considered the beginning of the interstellar medium.[84] Beyond the heliopause, at around 230 AU, lies the bow shock: a plasma "wake" left by the Sun as it travels through the Milky Way.[234] Large objects out

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surface have been estimated to lie between about −20 °C (253 K) with the Sun overhead, dropping to about −190 °C (83.1 K) at the winter pole. Typical daytime and nighttime temperatures are −60 °C (213 K) and −130 °C (143 K), respectively. This estimate is for 6 May 1996, very close to perihelion, although details vary somewhat with the seasons.[16] Further information: List of geological features on Vesta Before the arrival of the Dawn spacecraft, some Vestan surface features had already been resolved using the Hubble Space Telescope and ground-based telescopes (e.g., the Keck Observatory).[68] The arrival of Dawn in July 2011 revealed the complex surface of Vesta in detail.[69] Geologic map of Vesta (Mollweide projection).[70] The most ancient and heavily cratered regions are brown; areas modified by the Veneneia and Rheasilvia impacts are purple (the Saturnalia Fossae Formation, in the north)[71] and light cyan (the Divalia Fossae Formation, equatorial),[70] respectively; the Rheasilvia impact basin interior (in the south) is dark blue, and neighboring areas of Rheasilvia ejecta (including an area within Veneneia) are light purple-blue;[72][73] areas modified by more recent impacts or mass wasting are yellow/orange or green, respectively. Main articles: Rheasilvia and Veneneia Northern (left) and southern (right) hemispheres. The "Snowman" craters are at the top of the left image; Rheasilvia and Veneneia (green and blue) dominate the right. Parallel troughs are seen in both. Colors of the two hemispheres are not to scale,[j] and the equatorial region is not shown. South pole of Vesta, showing the extent of Rheasilvia crater. The most prominent of these surface features are two enormous impact basins, the 500-kilometre-wide (311 mi) Rheasilvia, centered near the south pole; and the 400-kilometre-wide (249 mi) Veneneia. The Rheasilvia impact basin is younger and overlies the Veneneia.[74] The Dawn science team named the younger, more prominent crater Rheasilvia, after the mother of Romulus and Remus and a mythical vestal virgin.[75] Its width is 95% of the mean diameter of Vesta. The crater is about 19 km (12 mi) deep. A central peak rises 23 km (14 mi) above the lowest measured part of the crater floor and the highest measured part of the crater rim is 31 km (19 mi) above the crater floor low point. It is estimated that the impact responsible excavated about 1% of the volume of Vesta, and it is likely that the Vesta family and V-type asteroids are the products of this collision. If this is the case, then the fact that 10 km (6 mi) fragments have survived bombardment until the present indicates that the crater is at most only about 1 billion years old.[76] It would also be the site of origin of the HED meteorites. All the known V-type asteroids taken together account for only about 6% of the ejected volume, with the rest presumably either in small fragments, ejected by approaching the 3:1 Kirkwood gap, or perturbed away by the Yarkovsky effect or radiation pressure. Spectroscopic analyses of the Hubble images have shown that this crater has penetrated deep through several distinct layers of the crust, and possibly into the mantle, as indicated by spectral signatures of olivine.[58] Subsequent analysis of data from the Dawn mission provided much greater detail on Rheasilvia's structure and composition, confirming it as one of the largest impact structures known relative to its parent body size.[74] The impact clearly modified the pre-existing very large, Veneneia structure, indicating Rheasilvia's younger age.[74] Rheasilvia's size makes Vesta's southern topography unique, creating a flattened southern hemisphere and contributing significantly to the asteroid's overall oblate shape.[69] Rheasilvia's ~22 km (14 mi) central peak stands as one of the tallest mountains identified in the Solar System.[74] Its base width of roughly 180 km (110 mi) and complex morphology distinguishes it from the simpler central peaks seen in smaller craters.[77] Numerical modeling indicates that such a large central structure within a ~505 km (314 mi) diameter basin requires formation on a differentiated body with significant gravity. Scaling laws for craters on smaller asteroids fail to predict such a feature; instead, impact dynamics involving transient crater collapse and rebound of the underlying material (potentially upper mantle) are needed to explain its formation.[77] Hydrocode simulations suggest the impactor responsible was likely 60–70 km (37–43 mi) across, impacting at roughly 5.4 km/s.[78] Models of impact angle (around 30-45 degrees from vertical) better match the detailed morphology of the basin and its prominent peak.[77] Crater density measurements on Rheasilvia's relatively unmodified floor materials and surrounding ejecta deposits, calibrated using standard lunar chronology functions adapted for Vesta's location, place the impact event at approximately 1 billion years ago.[79][70] This age makes Rheasilvia a relatively young feature on a protoplanetary body formed early in Solar System history. The estimated excavation of ~1% of Vesta's volume[74] provides a direct link to the Vesta family of asteroids (Vestoids) and the HED meteorites. Since Vesta's spectral signature matches that of the Vestoids and HEDs, this strongly indicates they are fragments ejected from Vesta most likely during the Rheasilvia impact.[27][79] The Dawn mission's VIR instrument helped to confirm the basin's deep excavation and compositional diversity. VIR mapping revealed spectral variations across the basin consistent with the mixing of different crustal layers expected in the HED meteorites. Signatures matching eucrites (shallow crustal basalts) and diogenites (deeper crustal orthopyroxenites) were identified, which usually correlate with specific morphological features like crater walls or slump blocks.[80][27] The confirmed signature of olivine-rich material, which were first hinted at by Hubble observations is strongest on the flanks of the central peak and in specific patches along the basin rim and walls, suggesting it is not uniformly distributed but rather exposed in distinct outcrops.[81][80] As the dominant mineral expected in Vesta's mantle beneath the HED-like crust,[10] the presence of olivine indicates the Rheasilvia impact penetrated Vesta's entire crust (~20–40 km (12–25 mi) thick in the region) and excavated material from the upper mantle.[81] Furthermore, the global stresses resulting from this massive impact are considered the likely trigger for the formation of the large trough systems, like Divalia Fossa, that encircle Vesta's equatorial regions.[82][69] The crater Aelia Feralia Planitia, an old, degraded impact basin or impact basin complex near Vesta's equator (green and blue). It is 270 km (168 mi) across and predates Rheasilvia (green at bottom) Several old, degraded craters approach Rheasilvia and Veneneia in size, although none are quite so large. They include Feralia Planitia, shown at right, which is 270 km (168 mi) across.[83] More-recent, sharper craters range up to 158 km (98 mi) Varronilla and 196 km (122 mi) Postumia.[84] Dust fills up some craters, creating so-called dust ponds. They are a phenomenon where pockets of dust are seen in celestial bodies without a significant atmosphere. These are smooth deposits of dust accumulated in depressions on the surface of the body (like craters), contrasting from the Rocky terrain around them.[85] On the surface of Vesta, we have identified both type 1 (formed from impact melt) and type 2 (electrostatically made) dust ponds within 0˚–30°N/S, that is, Equatorial region. 10 craters have been identified with such formations.[86] The "snowman craters" are a group of three adjacent craters in Vesta's northern hemisphere. Their official names, from largest to smallest (west to east), are Marcia, Calpurnia, and Minucia. Marcia is the youngest and cross-cuts Calpurnia. Minucia is the oldest.[70] "Snowman" craters by Dawn from 5,200 km (3,200 mi) in 2011Detailed image of the "Snowman" craters The majority of the equatorial region of Vesta is sculpted by a series of parallel troughs designated Divalia Fossae; its longest trough is 10–20 kilometres (6.2–12.4 mi) wide and 465 kilometres (289 mi) long. Despite the fact that Vesta is a one-seventh the size of the Moon, Divalia Fossae dwarfs the Grand Canyon. A second series, inclined to the equator, is found further north. This northern trough system is named Saturnalia Fossae, with its largest trough being roughly 40 km (25 mi) wide and over 370 km (230 mi) long. These troughs are thought to be large-scale graben resulting from the impacts that created Rheasilvia and Veneneia craters, respectively. They are some of the longest chasms in the Solar System, nearly as long as Ithaca Chasma on Tethys. The troughs may be graben that formed after another asteroid collided with Vesta, a process that can happen only in a body that is differentiated,[82] which Vesta may not fully be. Alternatively, it is proposed that the troughs may be radial sculptures created by secondary cratering from Rheasilvia.[87] A section of Divalia Fossae, with parallel troughs to the north and southA computer-generated view of a portion of Divalia Fossae Compositional information from the visible and infrared spectrometer (VIR), gamma-ray and neutron detector (GRaND), and framing camera (FC), all indicate that the majority of the surface composition of Vesta is consistent with the composition of the howardite, eucrite, and diogenite meteorites.[88][89][90] The Rheasilvia region is richest in diogenite, consistent with the Rheasilvia-forming impact excavating material from deeper within Vesta. The presence of olivine within the Rheasilvia region would also be consistent with excavation of mantle material. However, olivine has only been detected in localized regions of the northern hemisphere, not within Rheasilvia.[32] The origin of this olivine is currently unclear. Though olivine was expected by astronomers to have originated from Vesta's mantle prior to the arrival of the Dawn orbiter, the lack of olivine within the Rheasilvia and Veneneia impact basins complicates this view. Both impact basins excavated Vestian material down to 60–100 km, far deeper than the expected thickness of ~30–40 km for Vesta's crust. Vesta's crust may be far thicker than expected or the violent impact events that created Rheasilvia and Veneneia may have mixed material enough to obscure olivine from observations. Alternatively, Dawn observations of olivine could instead be due to delivery by olivine-rich impactors, unrelated to Vesta's internal structure.[91] Pitted terrain has been observed in four craters on Vesta: Marcia, Cornelia, Numisia and Licinia.[92] The formation of the pitted terrain is proposed to be degassing of impact-heated volatile-bearing material. Along with the pitted terrain, curvilinear gullies are found in Marcia and Cornelia craters. The curvilinear gullies end in lobate deposits, which are sometimes covered by pitted terrain, and are proposed to form by the transient flow of liquid water after buried deposits of ice were melted by the heat of the impacts.[71] Hydrated materials have also been detected, many of which are associated with areas of dark material.[93] Consequently, dark material is thought to be largely composed of carbonaceous chondrite, which was deposited on the surface by impacts. Carbonaceous chondrites are comparatively rich in mineralogically bound OH.[90] Cut-away schematic of Vestan core, mantle, and crust Eucrite meteorite A large collection of potential samples from Vesta is accessible to scientists, in the form of over 1200 HED meteorites (Vestan achondrites), giving insight into Vesta's geologic history and structure. NASA Infrared Telescope Facility (NASA IRTF) studies of asteroid (237442) 1999 TA10 suggest that it originated from deeper within Vesta than the HED meteorites.[94] Vesta is thought to consist of a metallic iron–nickel core, variously estimated to be 90 km (56 mi)[63] to 220 km (140 mi)[10] in diameter, an overlying rocky olivine mantle, with a surface crust of similar composition to HED meteorites. From the first appearance of calcium–aluminium-rich inclusions (the first solid matter in the Solar System, forming about 4.567 billion years ago), a likely time line is as follows:[95][96][97][98][99] Timeline of the evolution of Vesta 2–3 million years Accretion completed 4–5 million years Complete or almost complete melting due to radioactive decay of 26Al, leading to separation of the metal core 6–7 million years Progressive crystallization of a convecting molten mantle. Convection stopped when about 80% of the material had crystallized Extrusion of the remaining molten material to form the crust, either as basaltic lavas in progressive eruptions, or possibly forming a short-lived magma ocean. The deeper layers of the crust crystallize to form plutonic rocks, whereas older basalts are metamorphosed due to the pressure of newer surface layers. Slow cooling of the interior Vesta is the only known intact asteroid that has been resurfaced in this manner. Because of this, some scientists refer to Vesta as a protoplanet.[100] Composition of the Vestan crust (by depth)[101] A lithified regolith, the source of howardites and brecciated eucrites. Basaltic lava flows, a source of non-cumulate eucrites. Plutonic rocks consisting of pyroxene, pigeonite and plagioclase, the source of cumulate eucrites. Plutonic rocks rich in orthopyroxene with large grain sizes, the source of diogenites. On the basis of the sizes of V-type asteroids (thought to be pieces of Vesta's crust ejected during large impacts), and the depth of Rheasilvia crater (see below), the crust is thought to be roughly 10 kilometres (6 mi) thick.[102] Findings from the Dawn spacecraft have found evidence that the troughs that wrap around Vesta could be graben formed by impact-induced faulting (see Troughs section above), meaning that Vesta has more complex geology than other asteroids. The impacts that created the Rheasilvia and Veneneia craters occurred when Vesta was no longer warm and plastic enough to return to an equilibrium shape, distorting its once rounded shape and prohibiting it from being classified as a dwarf planet today.[citation needed] Vesta's surface is covered by regolith distinct from that found on the Moon or asteroids such as Itokawa. This is because space weathering acts differently. Vesta's surface shows no significant trace of nanophase iron because the impact speeds on Vesta are too low to make rock melting and vaporization an appreciable process. Instead, regolith evolution is dominated by brecciation and subsequent mixing of bright and dark components.[103] The dark component is probably due to the infall of carbonaceous material, whereas the bright component is the original Vesta basaltic soil.[104] Some small Solar System bodies are suspected to be fragments of Vesta caused by impacts. The Vestian asteroids and HED meteorites are examples. The V-type asteroid 1929 Kollaa has been determined to have a composition akin to cumulate eucrite meteorites, indicating its origin deep within Vesta's crust.[28] Vesta is currently one of only eight identified Solar System bodies of which we have physical samples, coming from a number of meteorites suspected to be Vestan fragments. It is estimated that 1 out of 16 meteorites originated from Vesta.[105] The other identified Solar System samples are from Earth itself, meteorites from Mars, meteorites from the Moon, and samples returned from the Moon, the comet Wild 2, and the asteroids 25143 Itokawa, 162173 Ryugu, and 101955 Bennu.[29][k] Animation of Dawn's trajectory from 27 September 2007 to 5 October 2018 Dawn · Earth · Mars · 4 Vesta · 1 Ceres First image of asteroids (Ceres and Vesta) taken from Mars. The image was made by the Curiosity rover on 20 April 2014. Animation of Dawn's trajectory around 4 Vesta from 15 July 2011 to 10 September 2012 Dawn · 4 Vesta In 1981, a proposal for an asteroid mission was submitted to the European Space Agency (ESA). Named the Asteroidal Gravity Optical and Radar Analysis (AGORA), this spacecraft was to launch some time in 1990–1994 and perform two flybys of large asteroids. The preferred target for this mission was Vesta. AGORA would reach the asteroid belt either by a gravitational slingshot trajectory past Mars or by means of a small ion engine. However, the proposal was refused by the ESA. A joint NASA–ESA asteroid mission was then drawn up for a Multiple Asteroid Orbiter with Solar Electric Propulsion (MAOSEP), with one of the mission profiles including an orbit of Vesta. NASA indicated they were not interested in an asteroid mission. Instead, the ESA set up a technological study of a spacecraft with an ion drive. Other missions to the asteroid belt were proposed in the 1980s by France, Germany, Italy and the United States, but none were approved.[106] Exploration of Vesta by fly-by and impacting penetrator was the second main target of the first plan of the multi-aimed Soviet Vesta mission, developed in cooperation with European countries for realisation in 1991–1994 but canceled due to the dissolution of the Soviet Union. Artist's conception of Dawn orbiting Vesta In the early 1990s, NASA initiated the Discovery Program, which was intended to be a series of low-cost scientific missions. In 1996, the program's study team recommended a mission to explore the asteroid belt using a spacecraft with an ion engine as a high priority. Funding for this program remained problematic for several years, but by 2004 the Dawn vehicle had passed its critical design review[107] and construction proceeded.[citation needed] It launched on 27 September 2007 as the first space mission to Vesta. On 3 May 2011, Dawn acquired its first targeting image 1.2 million kilometres (0.75×10^6 mi) from Vesta.[108] On 16 July 2011, NASA confirmed that it received telemetry from Dawn indicating that the spacecraft successfully entered Vesta's orbit.[109] It was scheduled to orbit Vesta for one year, until July 2012.[110] Dawn's arrival coincided with late summer in the southern hemisphere of Vesta, with the large crater at Vesta's south pole (Rheasilvia) in sunlight. Because a season on Vesta lasts eleven months, the northern hemisphere, including anticipated compression fractures opposite the crater, would become visible to Dawn's cameras before it left orbit.[111] Dawn left orbit around Vesta on 4 September 2012 11:26 p.m. PDT to travel to Ceres.[112] NASA/DLR released imagery and summary information from a survey orbit, two high-altitude orbits (60–70 m/pixel) and a low-altitude mapping orbit (20 m/pixel), including digital terrain models, videos and atlases.[113][114][115][116][117][118] Scientists also used Dawn to calculate Vesta's precise mass and gravity field. The subsequent determination of the J2 component yielded a core diameter estimate of about 220 km (140 mi) assuming a crustal density similar to that of the HED.[113] Dawn data can be accessed by the public at the UCLA website.[119] Albedo and spectral maps of 4 Vesta, as determined from Hubble Space Telescope images from November 1994 Elevation map of 4 Vesta, as determined from Hubble Space Telescope images of May 1996 Elevation diagram of 4 Vesta (as determined from Hubble Space Telescope images of May 1996) viewed from the south-east, showing Rheasilvia crater at the south pole and Feralia Planitia near the equator Vesta seen by the Hubble Space Telescope in May 2007 The 2006 IAU draft proposal on the definition of a planet listed Vesta as a candidate.[120] Vesta is shown fourth from the left along the bottom row. Vesta comes into view as the Dawn spacecraft approaches and enters orbit: Vesta from 100,000 km(1 July 2011) Vesta from 41,000 km(9 July 2011) In orbit at 16,000 km(17 July 2011) In orbit from 10,500 km(18 July 2011) The northern hemisphere from 5,200 km(23 July 2011) In orbit from 5,200 km(24 July 2011) In orbit from 3,700 km(31 July 2011) Full rotation(1 August 2011) Composite greyscale image Cratered terrain with hills and ridges(6 August 2011) Densely cratered terrain near terminator(6 August 2011) Vestan craters in various states of degradation, with troughs at bottom(6 August 2011) Hill shaded central mound at the south pole of Vesta(2 February 2015) Detailed images retrieved during the high-altitude (60–70 m/pixel) and low-altitude (~20 m/pixel) mapping orbits are available on the Dawn Mission website of JPL/NASA.[121] Annotated image from Earth's surface in June 2007 with (4) Vesta Its size and unusually bright surface make Vesta the brightest asteroid, and it is occasionally visible to the naked eye from dark skies (without light pollution). In May and June 2007, Vesta reached a peak magnitude of +5.4, the brightest since 1989.[122] At that time, opposition and perihelion were only a few weeks apart.[123] It was brighter still at its 22 June 2018 opposition, reaching a magnitude of +5.3.[124] Less favorable oppositions during late autumn 2008 in the Northern Hemisphere still had Vesta at a magnitude of from +6.5 to +7.3.[125] Even when in conjunction with the Sun, Vesta will have a magnitude around +8.5; thus from a pollution-free sky it can be observed with binoculars even at elongations much smaller than near opposition.[125] In 2010, Vesta reached opposition in the constellation of Leo on the night of 17–18 February, at about magnitude 6.1,[126] a brightness that makes it visible in binocular range but generally not for the naked eye. Under perfect dark sky conditions where all light pollution is absent it might be visible to an experienced observer without the use of a telescope or binoculars. Vesta came to opposition again on 5 August 2011, in the constellation of Capricornus at about magnitude 5.6.[126][127] Vesta was at opposition again on 9 December 2012.[128] According to Sky and Telescope magazine, this year Vesta came within about 6 degrees of 1 Ceres during the winter of 2012 and spring 2013.[129] Vesta orbits the Sun in 3.63 years and Ceres in 4.6 years, so every 17.4 years Vesta overtakes Ceres (the previous overtaking was in April 1996).[129] On 1 December 2012, Vesta had a magnitude of 6.6, but it had decreased to 8.4 by 1 May 2013.[129] Conjunction of Ceres and Vesta near the star Gamma Virginis on 5 July 2014 in the Constellation of Virgo. Ceres and Vesta came within one degree of each other in the night sky in July 2014.[129] 3103 Eger 3551 Verenia 3908 Nyx 4055 Magellan Asteroids in fiction Diogenite Eucrite List of former planets Howardite Vesta family (vestoids) List of tallest mountains in the Solar System ^ Marc Rayman of the JPL Dawn team used "Vestian" (analogous to the Greek cognate Hestian) a few times in 2010 and early 2011 in his Dawn Journal, and the Planetary Society continued to use that form for a few more years.[2] The word had been used elsewhere, e.g. in Tsiolkovsky (1960) The call of the cosmos. However, otherwise the shorter form "Vestan" has been used by JPL.[3] Most modern print sources also use "Vestan".[4][5]Note that the related word "Vestalian" refers to people or things associated with Vesta, such as the vestal virgins, not to Vesta herself. ^ Calculated using the known dimensions assuming an ellipsoid. ^ Calculated using (1) the known rotation period (5.342 h)[6] and (2) the equatorial radius Req (285 km)[10] of the best-fit biaxial ellipsoid to Asteroid 4 Vesta. ^ a b topocentric coordinates computed for the selected location: Greenwich, United Kingdom[14] ^ On 10 February 2009, during Ceres perihelion, Ceres was closer to the Sun than Vesta, because Vesta has an aphelion distance greater than Ceres's perihelion distance. (10 February 2009: Vesta 2.56 AU; Ceres 2.54 AU) ^ 維斯塔 wéisitǎ is the closest Chinese approximation of the Latin pronunciation westa. ^ Some sources contemporaneous to Gauss invented more elaborate forms, such as and .[43][44] A simplification of the latter from c. 1930, ,[45] never caught on. ^ This symbol can be seen in the top of the most elaborate of the earlier forms, . It dates from 1973, at the beginning of astrological interest in asteroids.[46] ^ The data returned will include, for both asteroids, full surface imagery, full surface spectrometric mapping, elemental abundances, topographic profiles, gravity fields, and mapping of remnant magnetism, if any.[53] ^ that is, blue in the north does not mean the same thing as blue in the south. ^ Note that 6 Hebe may be the parent body for H chondrites, one of the most common meteorite types. ^ "Vesta". Dictionary.com Unabridged (Online). n.d. ^ "Search Results". Planetary Society. Archived from the original on 27 July 2020. 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