Feats and Footprints: Our Relationship with Earth

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This Science On a Sphere® script was written with a target audience of ages 14 and older (high school and above) in mind. However, easy modifications can be made to include a wider age range. For example, you can revise the audience questions to make them more targeted and make the explanations less technical to appeal to younger audience members. The directions in each section correspond to the script paragraph of the same letter.

****Please note*****: *dataset #5 (Paleo Geographic) and its corresponding script and directions are to be included only if the Paleo Geographic dataset is available for use at your location. If Paleo Geographic is not available, the entire section may be ignored.*

Dataset Title:	Script:	Directions:
1. Blue Marble, 23° tilt	*(Introduce SOS according to your location's procedures, below is a sample introduction.)* A. Welcome to Science On a Sphere®! SOS was invented by Dr. MacDonald, current director of the NOAA Earth System Research Laboratory as a new and more natural way to display scientific information. Four projectors are used to project images onto the sphere, each calibrated so that the images blend together and appear united. The sphere itself is made of carbon fiber and is suspended from the ceiling by wires. It is hollow and weighs a little over 50 pounds. B. What you are looking at of course, is our planet, Earth, as seen from space. This image, called the Blue Marble, was created by NASA satellites. It took four months to compile the Blue Marble imagery, because the hundreds of satellite images of the land and ocean could only be used when there were no clouds around. Then, afterward, the clouds	A. *Point to the projectors, wires, and other objects as you reference them so audience members are not distracted by trying to find them themselves.*

	were added on top. C. Our Earth is estimated to be 4.6 *billion* years old. It's an amazing planet, home to one massive ocean (with four ocean basins), seven continents, and thousands of mountains and volcanoes—but what really makes Earth a one-of-a-kind planet is that it is full of life! One life form in particular has learned to harness Earth's great resources more than others, and for that reason has come to dominate the planet. That's right, I'm talking about us—good old *Homo sapiens*. Thanks to our unique problem solving abilities, we have been able to adapt quickly in an ever-changing world, and in doing so we have made quite a mark on our planet. Today, we are going to take a look at the feats we've accomplished and the footprints we've left… *(*****Note for the presenter****: do not include the following paragraph if you* ***are*** *using the Paleo Geographic section.**)* Anatomically modern humans appeared only 200,000 years ago. In fact, if we scaled the Earth's age to one day, with Earth's formation being at hour 00:00 (midnight) and the present being hour 24:00 (midnight of the next day), then *homo sapiens* would have only appeared at 23:59:30—thirty seconds before midnight! That is a humbling thought. It gives us some perspective as we begin to assess our first feat: populating the globe.	
2. Paleo Geographic ***Only include Paleo Geographic if available at your location. If not, this dataset, script, and directions may be*	A. It has taken millions and millions of years for Earth to reach its present-day state. This simulation takes us through the early stages of Earth, before life forms developed, all the way to current day. It shows us how the shifting of Earth's crust—called plate tectonics—has shaped our planet throughout time. To create this simulation, scientists gathered and analyzed rocks from around the world, connecting land masses at times when	A. *Pause the dataset once it loads (or have the animation set to 0), so that you can introduce it.*

*excluded.***	their geology was identical and separating them when their geology differentiated. B. The explosive reproduction of very primitive animals (such as sponges and coral) began around 500 million years ago (mya) during the Cambrian. Dinosaurs were at their height 170mya during the Jurassic, and small mammals evolved around this time too. At 65mya the Cretaceous-Tertiary extinction event occurred and dinosaurs disappeared, likely due to a huge asteroid impact near the Yucatan Peninsula. Finally, just 200,000 years ago, anatomically modern *homo sapiens* appeared, originating in central Africa. So, while we sure don't act like the new species on the block, humans are in fact still in the embryonic stage. This gives us some perspective as we begin to assess our first feat: populating the globe. . .	B. *Pause the dataset at each of the milestones of life. Move the **Pointer** (via **Annotate**) around important areas and features, such as the Yucatan Peninsula for the dinosaur extinction event, and central Africa for the appearance of humans.*
3. Population Movie (frames 9549-10197 without audio)	A. The last 200 or so years in particular have been a time of exponential growth. In 1804, we reached our first ever billion population marker. We've reached *six* more since then—breaking the seven billion mark in March, 2012. B. This animation illustrates the population increase between 1804 and 2012, with each white dot representing one million people. The growth is pretty stunning, isn't it? And it is not without consequence. . .	A. *Pause the dataset as soon as it loads (or have the animation set to 0) so that you can give your explanation without distractions.* B. *Resume play of the dataset*
4. Earth at night	A. This is an image displaying the nighttime lights of the world, developed from satellites specially programmed to sense light. Areas with the most lights are brightest, and tend to indicate dense populations. Notice that the tendency for populations to settle near bodies of water is still apparent even today—just look at how populated the coastal areas are, as well as the Nile and Indus river valleys.	A. *Move the **Pointer** (via **Annotate**) along the coastlines of continents, Trans-Siberian RR, Nile and Indus river valleys, and other areas of interest to illustrate varying global*

	As our numbers continue to rise, so will the demand for electricity; this image will only get brighter and brighter and our footprint will get bigger and bigger.	*population densities (may wish to **zoom** into these areas as well).*
5. GFDL A1B Temp Change 1870-2100	Most of the electricity that we use today is generated from the burning of carbon-based fossil fuels: coal, oil, and natural gas. Burning these fuels releases excess carbon dioxide into the atmosphere. Now, as I'm sure you already know, CO_2 is a greenhouse gas, and by adding more and more of it into our atmosphere we risk enhancing the greenhouse effect and thus contributing to the warming of our planet. A. This animation models rising CO_2 levels and resulting temperature increases from 1870-2100. It uses both historical data and model forecast data. It was created for the Inter-governmental Panel on Climate Change, with the year 2000 being the base year. The CO_2 parts per million counter here keeps track of how much CO2 is in the atmosphere. Red areas signify temperatures that are warmer relative to the year 2000, blue areas signify temperatures that are cooler relative to the year 2000. The model is based on the A1B scenario, which in essence means "business as usual": continued population growth until 2050, continued use of fossil fuels at current rates, and continued development of new energy technologies. B. As you can see, by the year 2100, drastic changes have occurred (based on the model). Atmospheric CO2 content has reached 717ppm, and temperatures over land have increased significantly (North America's average temperature increases by 8.8°F, e.g.).	A. *Move the **Pointer** (via **Annotate**) around the CO_2 ppm counter and temperature color bar on the sphere as you mention them.* B. *Begin playing the dataset. Pause when the year 2100 is reached.* B. *Move the **Pointer** (via **Annotate**) around the CO2 counter again to point out the 717ppm of CO2 reached.* B. *Move the **Pointer** (via **Annotate**) around*

		land areas to stress how much warmer they have become. B. *You may wish to replay the dataset to give viewers another opportunity to see the A1B scenario outcome.*
6. Ocean Acidification Saturation State	Burning fossil fuels doesn't just affect our atmosphere, though. Up to one half of the CO2 released into the air gets absorbed by the ocean. This is causing the ocean to become less basic over time. Ocean acidification is putting stress on sea creatures that rely on carbonate ions—which are more plentiful in basic ocean waters—to create their hard shells/skeletons. A. This dataset illustrates the changes in ocean carbonate chemistry from 1895 to 2094. It was created using both historical carbonate measurements and model data which forecasts future conditions, assuming CO2 levels increase at their current rate. The gray dots you see on the dataset are corals, creatures heavily dependent on carbonate ions. Dark gray dots are cold water corals and light gray dots are warm water corals. B. As the animation runs, note the color bar on the side. As the ocean becomes less basic, the color changes from blue, to green, to orange, and then to gray. Notice how this change depicted along the color bar affects the corals and the snail. At first there is a plentiful amount of coral, and the snail is happy, but then, as ocean acidity increases, the number of corals decrease and the snail stops smiling. Eventually, according to this model, the ocean becomes too acidic to support the snail; the snail disappears and the one remaining coral is very weak. C. Corals, snails, and other carbonate-dependent	A. *Move the **Pointer** (via **Annotate**) around the gray dots as you mention them.* B. *Begin playing the dataset. Pause when 2094 is reached.* B. *Move the **Pointer** (via **Annotate**) around the severely distressed corals in the dataset. Also point out the snail along the color bar as you mention it.* B. *You may wish to replay the dataset to show audiences the acidification scenario again.*

	ocean creatures (such as sea urchins, crabs, and planktonic mollusks) provide a major food source for other organisms; their disappearance will affect the entire food chain: fish, marine mammals, birds, and humans too. So, in our growing population and its increasing demand for energy, we are leaving a footprint on the Earth in a very real way.	
7. Air Traffic with Day/Night Terminator	Another feat we've achieved is global connectivity. Trains, boats, cars, buses, subways . . . all of these modern machines can quickly and conveniently take us from place to place. No method of transportation, however, has connected our world as much as flight. That's right, these aren't little yellow tadpoles swimming across the globe, they're airplanes! A. This dataset tracks the paths of all the commercial flights within a 24-hour period (from the year 2007). It was created using the data from aircraft transponders, which are required to be onboard on any plane flying higher than 18,000ft (i.e. commercial aircraft). Notice how the flight activity changes with sunrise and sunset around the globe. For instance, in Europe, things really settle down after dark. In the U.S. the situation is similar, except for those planes that are headed across the pond, which take off just before midnight (24:00). Many flights to Europe take off at night so that they can arrive in London, Paris, Rome etc. in the morning. Conversely, flights to the U.S. from Europe tend to leave after dawn. Besides being fascinating to watch, this dataset does a great job of showing how, thanks to the feat of flight, we can now get to almost any destination in the world within 24 hours. Impressive, huh? Think how far we've advanced in just one century!	A. *Move the **Pointer** (via **Annotate**) around Europe when it is dark to show how it quiets down.* A. *Move the **Pointer** (via **Annotate**) along the overnight flights from the U.S. to Europe, and the return flights from Europe to the U.S. that take off after dawn.*

8. Global Epidemic Mobility Monitor—H1N1 Scenario	A. We are leaving behind footprints in our pursuit of greater global connectivity as well. Some of these footprints are negatively affecting our own species. For example: the accelerated and assisted spread of disease. You can witness this yourself by watching this animation, which tracks the 2009 outbreak of the H1N1 "swine" flu virus. As an infected person travels from an infected area to an *un*infected area, a red line is drawn connecting the line of travel. Note that the long lines of travel are made possible thanks to airplanes! Areas affected by the virus are then colored red: the darker the red, the larger number of people infected. Did anyone notice where the virus originated? I'll play the animation again... did you figure it out? *(Central America)* Yes! The virus originates in Central America (La Puebla, Mexico), but soon spreads across both oceans and into almost every corner of the world. So, even though expanding and connecting the global human society are very remarkable feats, the footprints we are leaving behind carry with them a new set of problems. . . but that doesn't mean we can't solve them! The human civilization of the 21st century is working together in unprecedented ways to meet some of our most daunting challenges, including pollution reduction and increased health standards.	A. *Pause the dataset as soon as it loads (or have the animation set to 0) while you introduce the dataset. Resume play when the introduction is complete.* A. *Replay the dataset after you ask the audience if they know where the outbreak originated to allow time to formulate a response.* A. *Once a correct response to the origin of the outbreak has been given,* ***draw*** *a circle around Central America to direct the audience's attention there and play the dataset a third time.*
9. Facebook (without label)	A. International, cross-cultural communication is in and of itself another feat—and I wouldn't hesitate to bet that you helped achieve it! How? Well, chances are you are part of a revolutionary communication network like the one represented here. Does anyone know what this is? I'll give you a hint: Mark Zuckerberg is responsible for it. *(Facebook!)* That's right, this is the world according to Facebook friendships!	A. *Move the* ***Pointer*** *(via* ***Annotate****) around the dataset to draw the audience's attention toward it as you ask them what they think it is.*

	B. In this map, continental and political borders are defined only by Facebook activity. It's no surprise that the U.S. and Europe are very clearly defined—we love our Facebook!—but you may be surprised to notice how well some of the developing nations of the world are also utilizing this form of communication. Just look at Eastern/South Eastern Europe, India, and Southeast Asia. One country is notoriously absent from this dataset, though. . .any guesses as to which one? *(China)* Yep. . . unfortunately China and Facebook are still not friends. Even though Facebook may seem trivial, it is an important medium of communication in our global society. As you can see from this image, the internet can link two communities together that were separated previously. The popularity of Facebook and other social networking sites shows us how much more open to communication we are today, and how much easier that communication is.	B. *Point to the U.S., Europe, Mid-East, India, and SE Asia with the* ***Pointer*** *(via* ***Annotate****) as you mention them.* B. *Move the* ***Pointer*** *(via* ***Annotate****) around the blank space where China is supposed to be to emphasize that nation's absence.*
10. Blue Marble with Nightlights	Earth. It is an amazing planet, and the only place we call home. Its unique atmosphere has allowed living things to exist and evolve for millions and millions of years—humans are only a very recent addition. But in the little time we've been here we've already accomplished several feats, including: rapid population growth, accessibility to the entire world, and increased global communication. Unfortunately, we've left some less appealing footprints on our planet and our own species in the process. But, do we stop progressing? Of course not! Progress, ingenuity, innovation, discovery—these traits are hard-wired into the *homo sapiens* genome. As long as we continue to educate ourselves and work together to solve problems, our future is bright! *(Give your location's customary farewell. Below is a sample.)* Thank you all for coming, I hope you enjoyed this	

	presentation of Science On a Sphere®. Please feel free to stick around for a few minutes and ask any questions.	