1. Robert Hazen, a geologist and mineralogist thinks that ___________________ may have played a fundamental part in the origin of life.

2. People are interested in meteorites because they are some of the oldest objects in our solar system, being nearly 4.6 _______________ years old. They are the very first _______________ in our solar system, and they came together to build the planets.

3. At first Earth and the other rocky planets were hot, molten magma even on the surface that in the coldness of space began to cool and change. No rocks or even specks of dust are believed to have survived from this period of what Hazen calls “Black Earth”. When the magma cooled it covered Earth with a black rock called _______________.

4. Rocks are made up of _______________ like quartz or diamonds. Looking through a microscope at super-thin slices of rock you can identify the minerals that make up the rock. And minerals are a source of most of the _______________, nature’s building blocks.

5. It is estimated that the meteorites (from asteroids and comets) that formed earth contained only about _______________ minerals. The heat and pressure of our early Earth allowed the formation of new minerals, and this changed the appearance of our Earth from black to gray.

6. Yosemite National Park is a relatively _______________ piece of Earth, but the kind of rock that makes up the cliffs of Yosemite goes back much further. The huge walls in Yosemite are made of _______________.

7. The key to life and the “Blue Earth” was liquid water. Exactly how long it took for Earth to become a blue planet is still a mystery. To study that mystery Hazen and other geologists go to the Pilbara, in western Australia which is one of the _______________ places on Earth. John Valley of the University of Wisconsin is interested in finding the mineral zircon that might date these rocks all the back to 4.4 billion years. The zircons are rare sand sized crystals that have weathered out of older rocks and now found in sedimentary sandstone rock. The tiny, long lasting zircon found in these rocks are the _______________ pieces of our planet ever discovered. These zircons were created 4.3 billion years ago and indicate they were formed in the presence of liquid _______________.

8. Jeffrey Bada of the Scripps Institution of Oceanography, has spent much of his life studying the “soup” of chemicals that might be present in water on the early Earth. He studied under Stanley Miller who was a pioneer in this field way back in the early 19___s. Miller and and his teacher Nobel Prize winning Harold Urey circulated water vapor in an atmosphere of methane and ammonia. They added a spark in the flask to represent _______________. What happen? They got amino acids which is the chemical building block of proteins. Some newspaper headlines at the time were saying “life created in the laboratory!” Of course the papers were wrong. That has never happened from any experiment. Still the implications were that maybe life could have started this way on the early Earth.

9. But then, 24 years later, came a new discovery that changed many ideas. On the dark ocean floor more than a mile below the surface, new ecosystems was found. These were around hot mineral-rich hydrothermal _______________. Here temperatures reached more than 600 degrees, and here life was thriving without the sun’s energy. Instead of the warm shallow pond idea, could this have been the kind of environment where life got started? So Hazen tried a Urey-Miller type experiment under conditions of high pressure and temperature like found at the hydrothermal vents. What they found in their gold tube was that _______________ happened. Then Hazen’s group recreated the early Earth cocktail but put some ground _______________ in the mix. This time they got amino acids.
10. Other scientists like Peter Coveney of the University College London, are looking a
____________________ which contains clay minerals. Clays have atomic spaces between the
crystals layers that can fill up with water and other molecules. This environment can help more
complex molecules, potentially like RNA, to form. The essential idea is: what seems important in
organic chemical reactions is both the ingredients and the _________________.

11. Rocks in Australia that are 3.4 billion years old have remnants of life known as stromatolites.
800 miles away, but still in Australia, living stromatolites can be found at ________________
Bay. David Flannery, a geologist with the NASA Jet Propulsion Laboratory, explains that without
these very rare living stromatolites, we wouldn’t be able to interpret these fossils in the rocks. In
other words we would not know how stromatolites were _________________. Stromatolites are
the very oldest fossils we know about, dated to 3.5 billion years.

12. While Stromatolites are the oldest fossils, that does not make the earliest form of life. Ruth
Blake a geologist at Yale University is trying to find evidence for earlier life. She is grinding up
very old rock from Greenland that formed on an ancient sea floor. She is looking for a chemical
____________________ of life. Blake believes she has found these signatures from 3.8 billion
years ago.

13. If you could go back to 3.8 billion years, the earth would not look much different than today
except you would die suffocating in that atmosphere rich in nitrogen and carbon dioxide but
lacking life giving free _________________. Microbes floating in water or on stromatolites
chemically began to change the chemistry of the our planet’s water and atmosphere, making the
“Red Earth”. This happened when microbes began to convert the ________________ energy
through photosynthesis.

14. The early oceans were filled with dissolved iron, but as the seas filled with oxygen the iron
began to rust and sink to the bottom. This rusted iron formed vast deposits of iron ore that have
been mined for centuries. This phase of rusting created many new minerals on Earth. From 250
minerals at Earth’s start there is now more than _________________ known.

15. But Earth has had its ups and downs for life even after microbes had created a new
atmosphere. The “White Earth” was named for dramatic ________________ ages. Volcanoes
melting through the ice and spewing out carbon dioxide is believed to have change the climate
back to warmer conditions and to the “Green Earth” with its present conditions and life forms
starting about 540 ________________ years ago.

16. Hazen goes back to Morocco’s Anti-Atlas Mountains to study rocks of an ancient
____________________ some 520 million years ago. He wants to find trilobites. These fossils are
preserved because they secreted a _________________ made of calcite. It is interesting how
life (back then as now) can make _________________.

17. One of Hazen’s favorite places to see the intertwining of minerals and life is the Calvert Cliffs
along the Chesapeake Bay. People find _________________ teeth weathering our of cliffs that
may be 7 inches long from creatures 50 or 60 feet long dwarfing today’s Great Whites. And it was
the minerals produced by these creatures that allowed them to get so big and powerful. Here
they were feeding on _________________. This is the story of how rocks and minerals
may have changed life and how life changed minerals and rocks. It is a fascinating story to think
about, as even now our form of life is changing the Earth’s surface, the sea and the
__________________________ in ways we can contemplate but may not be able to control.