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## MINI-THRESHOLDS OF LIFE?

### Mini-Thresholds of Life

In this animated video, David Christian highlights some “mini-thresholds” that mark key changes in the evolution of life. The video ends with the appearance of the first mammals. After reading the text below and watching the video, you should be able to outline the story of how life changed in the past 3.8 billion years, from simple prokaryotes to highly complex mammals.

### Key questions

- 1 What journey did life take to generate the great biodiversity that exists today?
- 2 Do you think there are other “mini-thresholds of life?”

### Transcript: Mini-Thresholds of Life

Let's explore how life has changed and diversified since the emergence of organic molecules in basic cells. One way to view this process is through six mini-thresholds. A threshold is a sudden increase in complexity that gives rise to new, emergent properties, new qualities. Consider each mini-threshold for yourself. Does it mark something new and different, and if so, why?

Our first mini-threshold is photosynthesis. It's likely that the first prokaryotes evolved deep in the ocean in massive vents that provided them with chemical and heat energy. About 3.5 billion years ago some cells migrated to the ocean's surface and evolved to use vastly more abundant energy from the sun. The process they developed to do this is called photosynthesis.

It led to an energy bonanza and that enabled life to spread to many more places, and since oxygen is created as a by-product of photosynthesis, huge numbers of photosynthesizing prokaryotes over millions of years radically transformed our atmosphere from one rich in carbon dioxide to one richer in oxygen. Oxygen was poisonous for many species so they died off, but new species emerged that could use oxygen as an amazing chemical energy.

**0:11-0:44**

LIFE MOVED  
ACROSS SIX  
MINI-THRESHOLDS

**0:45-1:38**

FIRST  
MINI-THRESHOLD:  
PHOTOSYNTHESIS  
IS THE PROCESS BY  
WHICH CELLS USE THE  
SUN AS ENERGY

ATMOSPHERIC  
OXYGEN INCREASED,  
KILLING SOME  
SPECIES, ENABLING  
OTHERS

**1:38-2:19** Mini-threshold two is the emergence of eukaryotes about 2.5 billion years ago. These are more complex cells whose DNA is locked up inside a special case called the nucleus, which helps protect and preserve vital genetic information. Eukaryotes also contain tiny organs called organelles. Like the organs in your body, they perform special functions such as photosynthesis, or processing oxygen. This meant that eukaryotes could thrive in Earth's increasingly oxygen-rich atmosphere while many prokaryotes perished. That's a pretty important development since we are made entirely of eukaryotic cells.

**2:19-3:38** Around 1 billion years ago, we crossed mini-threshold number three, the introduction of the first multi-cellular organisms. In the same way specialized organelles came together to form more complex eukaryotes, different eukaryotes came together to form even more complex life forms. These organisms could contain billions of cells, each with a different function, but all sharing the same DNA so they worked together. With networks of specialized cells and cooperation, multicelled organisms could respond to changes in the environment in entirely new ways, further developing a key survival trait of life that we call homeostasis.

The development of brains is mini-threshold four. Multicelled organisms needed a way to coordinate all the activities going on inside them and this became the work of special nerve cells. In some organisms these cells began to cluster at the head and down the spinal cord to form the first brains. Organisms with brains could process much more information, and they could react to it in even more complex ways, which enabled richer and more sophisticated activities, like thinking, and perhaps even consciousness.

Mini-threshold number five is when life moves from the ocean to land. From about 475 million years ago, some multicellular organisms, beginning with plants and fungi, left the oceans for land. There was a great incentive, this new environment was rich in new opportunities for organisms that could find ways to survive. That was a challenge, though, as these organisms had to develop special skins to avoid drying out, special ways to breathe out of water, and new ways to reproduce. The modern equivalent would be humans trying to live in space.

**FOURTH  
MINI-THRESHOLD:  
BRAINS**

**3:38-4:17**  
**FIFTH  
MINI-THRESHOLD:  
LIFE MOVES  
ON TO LAND**

**4:17-5:37** Mammals, the forerunners of you and me, account for mini-threshold number six. The first animal to live on land may have been like a modern lungfish, but other land animals soon evolved, such as amphibians. These still needed to return to the water to reproduce. Then came reptiles like crocodiles or dinosaurs. These developed large, leathery eggs that could survive well away from water. Then about 250 million years ago, the first mammals appeared on Earth evolving from a branch of reptiles that loosely resembled birds. Mammals are warm-blooded, they're furry, and they don't lay eggs, and you and I are mammals.

SIXTH  
MINI-THRESHOLD:  
MAMMALS

Does the appearance of mammals really count as a mini-threshold, or is it just because we are mammals that we think so? What would be other candidates for mini-thresholds, by the way? The development of backbones? The ability to think? Or what about the concept of family?