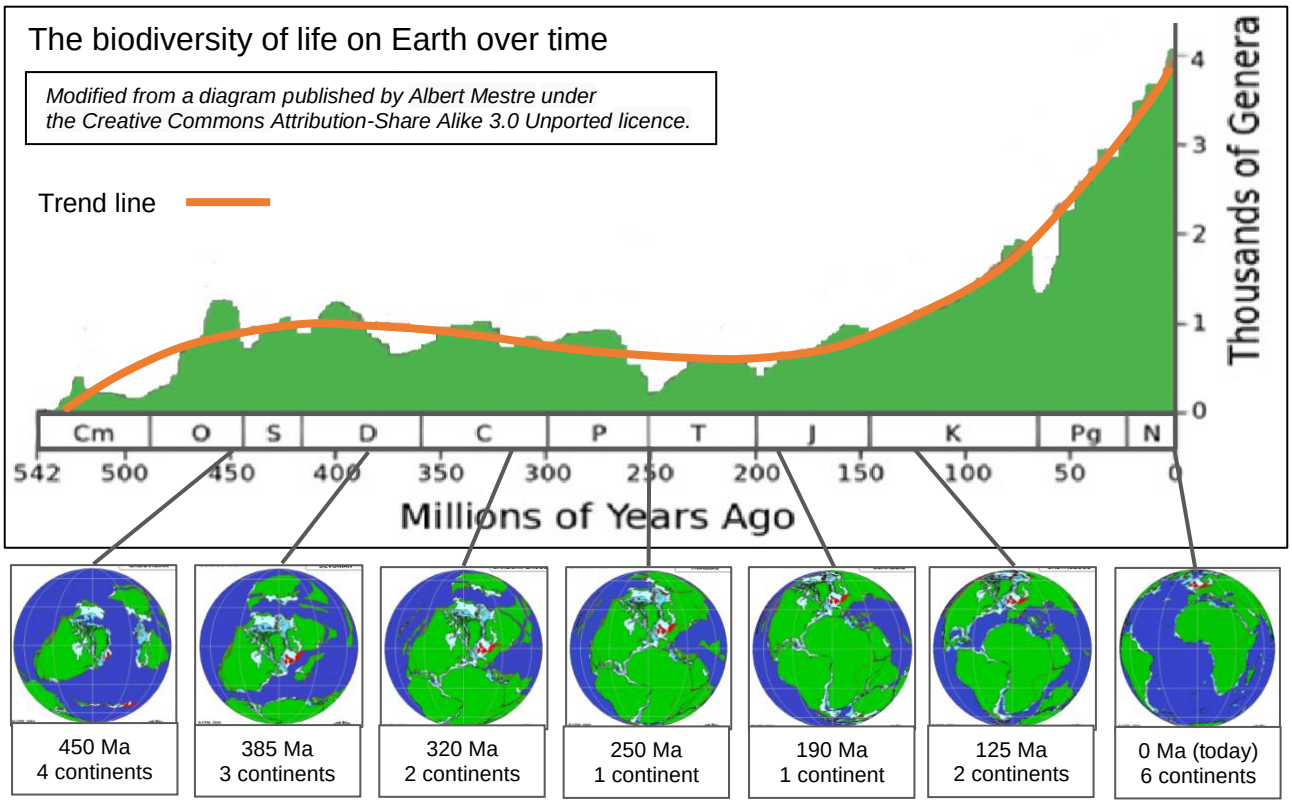
The pattern of continents/oceans versus the pattern of life on Earth

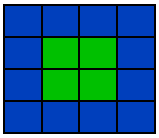
How can the link between continental patterns and life on Earth be explained?

The change in diversity of life on Earth (the biodiversity) is shown on this graph, together with the patterns of Earth's continents at different times.



The graph shows that in the past 450 million years, the smaller the number of continents, the lower the biodiversity of life on Earth.

Draw a model to show the areas of land, and the areas of shallow seas around the land, 450 million years ago, by drawing a 4 x 4 box of squares. Colour the four central continental 'land' squares green, and the surrounding continental shelf shallow 'sea' squares blue, like this:

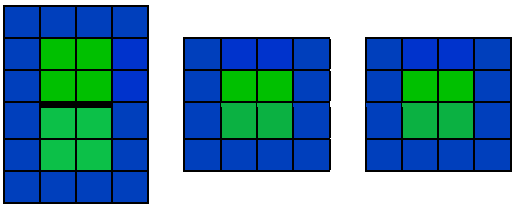


This represents one of the four continents. Count the number of green 'land' squares, multiply by 4 (for the four continents) and put the number in the correct row (450) of the table below. Repeat this for the number of 'sea' squares.

Age, Ma	No. continents	Total no. of 'land squares'	Total no. of 'sea' squares
0			
125			
190			
250			
320			
385			
450			

By 385 million years ago, two of the continents had collided to form one larger continent, but two continents had stayed separate.

Draw the continents 385 million years ago, with the collision zone having a thicker line, as:



Count the number of 'land' and 'sea' squares now and put the figures into the table.

Repeat this for the other continent patterns and put the figures into the table each time. (For the six continents of today, you will have to divide two of the four square continents into two and add sea areas).

The figures show that biodiversity is generally lowest when there are fewest continents and when shallow sea areas are connected.

This can be explained by:

- when each continent is separated from the others, the animals and plants on the land of each continent, and in its surrounding shallow seas, evolve and develop new species separately – giving great overall global biodiversity;
- when continents are together, species can move everywhere on land and in the shallow seas, there are fewer regional species, so giving overall reduced biodiversity worldwide.

The back up

Title: The pattern of continents/oceans versus the pattern of life on Earth.

Subtitle: How can the link between continental patterns and life on Earth be explained?

Topic: A modelling task, involving drawing and counting, to enable pupils to visualise the effects of different numbers of continents on global biodiversity.

Age range of pupils: 16 years upwards

Time needed to complete activity: 20 minutes

Pupil learning outcomes: Pupils can:
- draw different continental configurations, count the squares and plot the results into a table;
- use the table to describe a pattern between the numbers of continents and biodiversity;
- account for the findings in terms of the effects of differing numbers of continents and areas of shallow sea on evolution and extinction.

Context:
The lower scale bar of the top diagram on page 1 shows the periods of geological time as:

Carboniferous	C
Devonian	D
Silurian	S
Ordovician	O
Cambrian	Cm

Neogene	N
Paleogene	Pg
Cretaceous	K
Jurassic	J
Triassic	T
Permian	P

The table, when completed, looks like this:

Age, Ma	No. continents	Total no. of 'land squares'	Total no. of 'sea' squares
0	6	16	64
125	2	16	32
190	1	16	20
250	1	16	20
320	2	16	32
385	3	16	40
450	4	16	48

The general explanation for this pattern is:
a. most marine life is found on the continental shelf, and cannot cross deep oceans;
b. when a supercontinent has formed by collision, organisms mix on land and in the shallow seas, and so there will eventually be fewer species;
c. when the supercontinent splits into separate continents, each evolves its own fauna and flora because species cannot cross the intervening spaces and mix gene pools.

This simple picture is complicated by several factors – these include the following.
- Continents are not only being moved by plate tectonic forces but are also growing in size over time. Material from the mantle forms new island arc areas that are forced onto the margins of continents by plate collisions. When two continents collide, the mountain range formed in the collision zone from the sediments that were originally between the continents, also becomes new continental material, so enlarging continental areas.
- The fossil record improves over time, so may give the impression of better biodiversity in younger rocks.
- Biodiversity of living organisms today is much easier to estimate (and so may give much higher numbers) than estimates based on the fossil record.
- There seems to be a general trend of increasing biodiversity on Earth over time.

Following up the activity:
Ask the pupils to calculate the change in area of shallow sea habitat, caused by each collision or separation, as a percentage, and then comment on the results.

A. The effects of continental collisions on the model are even clearer when the results are calculated as percentages of loss or gain of the shallow sea areas.

From: (Ma)	*To: (Ma)*	*Change in no. 'sea' squares*	*% loss or gain*
124	*0*	*32-64 = 32 gain*	*32/32 = 100% gain*
190	*125*	*20-32 = 12 gain*	*12/20 = 60% gain*
320	*250*	*32-20 = 12 loss*	*12/32 = 38% loss*
385	*320*	*40-32 = 8 loss*	*8/40 = 20% loss*
450	*385*	*48-40 = 8 loss*	*8/48 = 17% loss*

They could calculate the effects of different continental shapes (of the same size) on the areas of shallow sea that result, for example:

Ask them how the following factors might affect the link between the number of continents and biodiversity:
- The difference in biodiversity between a continent being orientated North-South, and so covering several climatic belts and a continent of the same area being orientated East-West and so covering only one climatic belt.

A. For the East-West continent, animals and plants on land and in shallow seas all live in the same climatic belt, and so biodiversity remains low; meanwhile, a North-South continent covers several climatic belts, such as tropical, temperate or polar, each with its own species, and so its overall biodiversity can be much higher.

- How a mountain range across a continent might affect biodiversity.

A. The mountain range would have a similar effect to different climatic belts, reducing movement and providing more habitats – so increasing biodiversity.

- Why the continent versus biodiversity pattern works less well before 450 Ma.

A. *When biodiversity on Earth was lower, the trend of increasing biodiversity on Earth over time may have been more important than the number of continents.*

- What the effect of modern intercontinental travel might be on global biodiversity.

A. *Human activity transports species between continents, deliberately or not. This has the same effect as continental collision, in reducing global biodiversity. This may be one reason for the current high rates of extinction.*

Underlying principles:

- There seems to be a link between the number of continents at one time on Earth and the biodiversity at that time.
- This may be because when continents with their surrounding shallow sea areas are separated, separate paths of evolution can develop.
- However, when continents collide, species mix, and only those best fitted to the environment survive, reducing biodiversity.
- This simple pattern can become more complex if continents span several climatic zones or are divided by mountain ranges.

Thinking skill development:
The use of the data to show a pattern is a construction activity. Cognitive conflict is added when additional factors are considered. Discussions around the activity result in metacognition. Matching the simple model to the complexity of real world situations involves bridging skills.

Resource list:

- drawing and colouring materials

Useful links:
Try '*The Earth time jigsaw puzzle'* Earthlearningidea activity.

Source: Devised by Jo Conway, Coleg Cambria, Wrexham, North Wales. The helpful comments of Professor Mike Benton of Bristol University are much appreciated.