Worlds, big and small
Extract from "The search for infinity", solving the mysteries of the Universe, published by PHILIP'S

1) Introduction du document:

- What is the document composed of?
It is composed of a text and pictures.
- What do the pictures show?
The pictures show the different elements of our Universe on a distance scale.
They show a series of objects, greater and greater.
- The title and the introduction present 2 worlds and suggest 2 voyages: which ones?
It suggests a voyage towards the edge of the Universe, that is to say to a big world and another voyage to the minuscule world of matter.

2) Aborder le texte par morceau et, dans chaque morceau, sélectionner des informations:

I) Voyage to the microcosmos:

Read the text from line 1 to line 121 and complete the following table by finding the different stages of the voyage, the discovery at each stage, the device that allowed this discovery and its size.

a) Remplir la première ligne avec les élèves.
b) Laisser du temps pour la lecture et l'analyse du document.
c) Interroger les élèves pour corriger ligne par ligne.

line in the text	the device	the discovery	the size	The appropriate unit	the power of ten in metre
7	naked eye	the breadth of a hair	less than a millimetre (a twenty fifth of an inch)	mm	10^{-3}
16	magnifying glass or optical microscope	animalcules or bacteria	a micrometer (a hundred thousandth of an inch) a millionth of a metre	µm	10^{-6}
70	electron microscope	viruses		0.1 µm	10^{-7}
74	electron microscope	molecules		nm	10^{-9}
77	electron microscope	surface of individual atoms		A	10^{-10}
99	particle accelerators	nucleus		10 fm	10^{-14}
108	particle accelerators	quarks			10^{-18}
115		strings			10^{-33}

d) Focaliser sur un paragraphe plus particulièrement quand il apporte une idée à exploiter :

- Why cannot the eye distinguish a detail, smaller than a millimetre?
Because the eye cannot see something smaller than the distance between 2 sensitive cells of the retina.
- Why was Van Leeuwenhoek's discovery difficult to get accepted (to be agreed)?
Because of religion: God decided on the smallest creature. Thus it could not have a smaller one.

- What enabled the discovery of deeper layers of matter inside the nucleus?
Particle accelerators enabled the discovery of deeper layers of matter.
- Comment on the relation between the size of the smallest structure of matter and the size of the whole Universe?
The size of the smallest structure of matter is similar to the size of the Universe a fraction of second after the Big Bang.

e) Donner un prolongement scientifique au texte:

We can ask ourselves why we need such huge energies to see inside the matter.

To see an object, we need a light (or a wave) whose wavelength is the order of the object's size (or smaller). The visible light has a wavelength of about 0.5 μm (= 5. 10^{-7} m), thus we can see up to this size of matter (a bacteria for example).
But to see smaller things, we need other waves: UV (10^{-8} m), X (10^{-9} m), γ (10^{-14} m), which have smaller wavelength and greater energy.

Indeed, the energy E carried by a wave is proportional to its frequency f: $\boxed{E = h\,f}$
With h, Planck's constant h = 6.67 10^{-34} SI
And, as electromagnetic waves travel at the celerity of light c, c is also the number of wavelength covered by the wave per second, that is : $\boxed{c = \lambda.f}$

By rearranging f in E we obtain: $\boxed{E = h\,\dfrac{c}{\lambda}}$ with   c = 3.00 10^{8} m.s^{-1}

This explain why, to go deeper inside the matter, and to see even smaller details, we need even smaller wavelength and even greater energy.

Another way to get higher energies is to accelerate particles (protons or electrons for example) in larger accelerators like those of the CERN, in Geneva.
This explains why, accelerating particles allow to see deep inside the matter…

II) The voyage to the macrocosmos (to the edge of the Universe)

Read the text from line 122 to line 172 and complete the following table by finding the different stages of the travel, the discovery and the size of the discovery for each one.

line in the text	the celestial body	the distance	in km
127	our planet : the Earth	0	0
128	our star : the Sun	150 million km	1.5×10^{8}
130	our galaxy : the Milky Way	25 000 l.y from the centre	7.5×10^{17}
143	the closest star : Alpha Centauri	4 l.y	4×10^{13}
148	a cluster of stars : the Pleiades	400 l.y	4×10^{15}
151	the closest galaxy : Andromeda	2 million light-years	2×10^{19}
162	quasars	10,000 million l.y	1×10^{23}

1) **What is the appropriate unit of distance in astronomy?** → light year
2) **What does it correspond to in km?** → 10^{16} m = 10^{13} km
3) **Express these distances in km and with the scientific writing** → see the previous table
4) **How do both voyages join each other?** → Knowing the finest structure of matter would allow understanding what the Universe was composed of at the beginning.