TRAVELLING WITH LIGHT

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Complete read-through: 16 minutes

Read-through with pauses: 26 minutes + 1 minute for final credits

SEQUENCE 01: INTRODUCTION TO THE STORY.

MOTHER (O.S.)

Can you imagine what the world we live in

would be like without light?

CHILD (O.S.)

No, mum, I can't.

MOTHER (O.S.)

Why don't we try?

Come on, turn off the desk light, the one in the passage

and the one in the fish tank... oh!

and the one on the tablet.

CHILD (O.S.)

OK. I don't think we'll be able to do much,

but it'll be fun.

MOTHER (O.S.)

We'll hardly be able to see anything at first,

Because our eyes haven´t adjusted,

but in a few minutes you'll be surprised

how much we can see without those lights.

CHILD (O.S.)

I'll lower the blind as well to shut out

the light from the street.

SEQUENCE 02: OPENING CREDITS

SEQUENCE 03: THE CAVE AND OUR ANCESTORS

NARRATOR (O.S.)

When we discovered fire, our way of life changed dramatically;

up till then it had been limited to daytime,

but now we could live a nocturnal life after dark.

People used fire as a source of light and heat,

to protect themselves from possible predators...

and to cook food.

It was perhaps one of humanity's

most important discoveries.

SEQUENCE 04: NIGHT HUNTERS AND GLOW-WORMS

NARRATOR (O.S.)

Some animals can see much better than

we can in low light conditions.

This means they can hunt at night in the dark,

when they have hardly any competitors. Their eyes can capture more light.

NARRATOR (O.S.)

There are also others, like glow-worms,

that can give off light.

They have organs that react with a molecule,

called luciferin, producing light and heat.

SEQUENCE 05: INTRODUCING THE CHARACTERS.

CHILD (O.S.)

What if we light a candle,

like when there's a power cut?

CHILD

Everything really does look different like this.

I like it!

MOTHER

Yes... It's like when you read a book:

your imagination can take you wherever you want.

The thing is that when there was no

artificial light our ancestors could see

the stars much better at night.

SEQUENCE 06: AGRICULTURE "CARTOON".

NARRATOR (O.S.)

In prehistoric times,

people already knew the starry sky

and the periodic movements that took place in it.

Later on, they used them to establish the first calendars,

which they linked to their way of life, to hunting,

and then to agriculture.

Knowing the stars wasn't a hobby to them;

it was essential to their survival.

NARRATOR (O.S.)

For thousands of years

we've called this constellation Orion,

in historical times, when these stars

appeared in the sky,

there were frosts in the northern hemisphere.

Winter was coming...

NARRATOR (O.S.)

...With these stars in Leo, the frosts ended

and spring began.

This was vitally important in agriculture.

NARRATOR (O.S.)

When summer arrived, they could see

these three stars overhead.

Together, they form the Summer Triangle.

We call them Vega, Deneb and Altair.

And in Autumn, this big square called Pegasus appeared...

This happened and still happens repeatedly, year after year.

The stars are a calendar

written in the sky!

SEQUENCE 07: NAVIGATION "CARTOON".

NARRATOR (O.S.)

When there were no compasses, or satnavs, or mobile phones...

sailors far out at sea

also used the light from the stars to guide them.

NARRATOR (O.S.)

There’s a star that can be seen in the whole of the Earth’s

northern hemisphere. It’s not one of the brightest,

but it stays in the same place all night.

We see the other stars turn around it.

It’s the Pole Star,

and in addition to the latitude it shows you roughly which way is North.

Its light has been a guide for navigating the high seas.

You can find it from the plough
in the constellation of Ursa Major, the Great Bear,
following the direction marked
by Merak and Dubhe.

NARRATOR (O.S.)

But... the stars weren’t the only source of light
that sailors used to cross the sea...

SEQUENCE 08: LIGHTHOUSE OF ALEXANDRIA "CARTOON".

NARRATOR (O.S.)

The first lighthouses,
like the one in Alexandria or the Tower of Hercules,
also used fire as a source of light.
There was a fire in them, and ships used it as a reference
when they approached the coast;
it had to be kept burning constantly all night.

SEQUENCE 09: EYESIGHT.

CHILD

Ow!

MOTHER

What's the matter? Are you all right?

CHILD

Yes, I'm OK, but my eyes hurt.

MOTHER

Of course. Do you know why?

Our eyes had adjusted to the darkness

and when we suddenly switched the light on, we were blinded by the light.

Our eyes have to adapt slowly to those changes.

CHILD

That's true. Like when we switched the light off earlier.

It took a little while before

we began to make out shapes, didn't it?

CHILD

Hey, mum, yesterday in class the teacher told us

that there are people who confuse certain colours,

and that it's something to do with their eyes.

MOTHER

Yes, look.

NARRATOR (O.S.)

Our eyes capture the light

that reaches us from the objects around us

and we form images of them on our retina.

SEQUENCE 10: RODS AND CONES.

NARRATOR (O.S.)

The stimulation of nerve cells

on the retina is transmitted by the optic nerve

as an electrical impulse

to the brain,

which interprets the image we perceive.

That’s how we know the shapes and colours of things,

how far away they are, whether or not they’re moving...

NARRATOR (O.S.)

Light enters the eye through the cornea

and reaches the pupil.

The iris dilates or contracts to adapt

the diameter of the pupil to the amount of light available.

Behind it, the lens

changes shape, getting more curved or flatter,

to focus on the distance at which the object is situated

and form a sharp image on the retina.

NARRATOR (O.S.)

The retina is made up of millions of photosensitive

cells, known as cones and rods.

NARRATOR (O.S.)

The rods are distributed

around the edge of the retina;

they are more active at night

and they don’t distinguish colours.

NARRATOR (O.S.)

The cones, on the other hand, are concentrated in the

central area. They are involved in daytime vision

and they enable us to tell colours apart.

There are three different types,

for detecting red, green and blue.

When one of these types of cones is affected,

it causes changes in the corresponding colour.

NARRATOR (O.S.)

This genetic alteration in the way we perceive colours is called colour blindness, and a lot of people have it, although they can lead a completely normal life.

SEQUENCE 11: COLOUR BLINDNESS.

MOTHER

Can you see any numbers in these images?

If not, we may have to go and see the ophthalmologist...

CHILD

OK then, mum,

so light is there in everything around us, but where does all that light come from? Not this light here... or that one there.

MOTHER

I think I know what you mean.

Most of it comes from up there...

MOTHER

...from the stars.

CHILD

What?

MOTHER

Yes, up there...

SEQUENCE 12: THE SUN.

NARRATOR (O.S.)

Light is produced in here,

inside stars.

And also, of course, in the Sun.

Stars are gigantic balls of fire,

which shine because thermonuclear reactions

are taking place inside them:

four atoms of hydrogen

are converted into just one of helium.

By using up their own mass they are able to produce light,

heat and other forms of radiation: in other words, energy.

NARRATOR (O.S.)

Almost all the energy the Sun will emit during

its lifetime is produced in the form of photons.

NARRATOR (O.S.)

Long before it reaches the Earth,

a photon starts its journey in the Sun’s core.

Its energy takes about 170,000 years

to cross the first of the Sun’s layers,

where photons are absorbed and scattered

by the particles there, beginning a chaotic, almost endless

journey which prevents the photon from travelling freely.

NARRATOR (O.S.)

Once it’s got past that layer it reaches the convection zone,

where it’s pushed towards the outside

by huge columns of gas, until finally,

after crossing

the photosphere, the chromosphere and the solar corona,

it escapes from the sun.

NARRATOR (O.S.)

It travels the 150 million kilometres that separate

the Earth from the Sun in just

8 minutes!

NARRATOR (O.S.)

But not all photons are able to penetrate the Earth’s atmosphere.

Many are sent back into space

and others are absorbed by the atmosphere itself.

Those that do manage to reach the Earth’s

surface are vitally important to us.

SEQUENCE 13: PHOTOSYNTHESIS.

CHILD

Why are they so important?

MOTHER

Plants, algae

and some bacteria use the light from the Sun

to perform photosynthesis.

This is tremendously important to life on our planet.

They provide us with oxygen,

which is essential for breathing.

CHILD

So this plant produces the oxygen

we breathe!

MOTHER

From this chemical reaction, triggered by sunlight,

plants and other organisms

get the energy they need to live,

and also provide food for all the animals,

including us.

CHILD

Of course! Like fruit?

MOTHER

That’s right, fruit. Very good!

Plants are at the beginning of the food chain.

Other living creatures eat them,

and that’s how we get foods

like milk and meat.

NARRATOR (O.S.)

This very complex chemical reaction

is called the Calvin-Benson cycle;

it’s one of the most important in nature.

It consists of a set of biochemical processes

that take place during photosynthesis.

The carbon dioxide absorbed

through the pores of the leaves reaches the chloroplasts,

where the whole cycle is carried out.

As a result, glucose is formed, an organic molecule present in all living beings.

So to sum up, this cycle makes it possible for

inorganic material to be turned into organic material

and incorporated into many living beings

through their food.

CHILD

Mum, I understand that we couldn't live without light,

and that there would be no life on Earth without it...

...but...

MOTHER

What is it? Tell me...

CHILD

I'm finding it more and more difficult

to understand what light is...

MOTHER

Well now...

That's a very, very complicated question.

You're quite right to find it confusing.

It's taken science a long time

to answer that question.

SEQUENCE 14: NEWTON.

NARRATOR (O.S.)

Newton thought that light was made of little particles,

but his contemporary Huygens insisted it was a wave.

Both theories could explain

what was then known about light.

NARRATOR (O.S.)

Later, new experiments showed

that it must be a wave.

But what sort of wave?

Because up till that time,

all the known waves, such as sound,

needed a material medium to propagate,

and yet light

propagates in a vacuum at 300,000 kilometres a second!

Since the second half of the nineteenth century,

thanks to Maxwell,

we've known that light is an

electromagnetic wave.

NARRATOR (O.S.)

When that wave comes up against matter,

it behaves like a particle

in which all its energy is concentrated.

That particle is the photon we were talking about.

So light is a wave and a particle at the same time!

Since the twentieth century, thanks to Einstein, we've known

that nothing can travel faster than light!

Quantum Mechanics describes waves and particles

as one and the same thing.

SEQUENCE 15: ELECTROMAGNETIC WAVES

NARRATOR (O.S.)

The energy of each photon depends on the frequency
of the wave: in other words, the number of times
it oscillates per second. The greater the frequency, the more
energy it carries, and its effects are different.
The set of all frequencies is called the electromagnetic
spectrum...

NARRATOR (O.S.)

... and it ranges from radio waves,
microwaves,
which we use for heating food,
visible light,
ultraviolet light,
X rays,
which have enough energy to pass through skin and tissues
and show us our bones
in radiography,
up to gamma rays, which are the most energetic of all
and reach us from the Universe.

CHILD

So we can’t see all those other kinds of light?

MOTHER

Our eyes only let us see in this small part
of the electromagnetic spectrum
which can pass through the Earth’s atmosphere
and which we call visible light.
But with the help of technology,
we can get to know the Universe
by observing other sources of light.

Come on, I’ll show you.

MOTHER (O.S.)

"This here is the GRANTECAN.
It’s an enormous optical telescope
in the Canary Islands.
Scientists use it to study the night sky
in search of answers
to all the mysteries that have yet to be solved...."

SEQUENCE 16: LIGHT FROM THE UNIVERSE.

NARRATOR (O.S.)

Light from the whole Universe is still travelling to the Earth.

NARRATOR (O.S.)

Apart from the recently discovered gravitational waves,
all the information that reaches us
is in the form of light.
Human beings have invented all sorts of instruments
to detect it.

NARRATOR (O.S.)

From radio telescopes on the ground
to space telescopes capable of seeing infrared light,
ultraviolet and X rays.

So we can see nearby objects,
visible to the naked eye,
whose light takes just a few seconds
to reach the Earth...

NARRATOR (O.S.)

... such as the Moon...

NARRATOR (O.S.)

... some of the planets, which are light minutes away...

NARRATOR (O.S.)

... or comets, which develop visible tails

when they are closest to the Sun,

providing us with very valuable information

about the origins of the Solar System...

... distant objects,

whose light takes many years to reach us,

such as young stars,

some of them still with the nebulas they were born from...

NARRATOR (O.S.)

old stars, at the end of their lives, at the

centre of the nebula they expelled when they died...

NARRATOR (O.S.)

and we can look at galaxies like Andromeda,

the most distant object we can see with the naked eye,

whose light started out over two million years ago!...

NARRATOR (O.S.)

... and obtain magnificent images

of thousands of galaxies and clusters of galaxies

with large telescopes.

NARRATOR (O.S.)

There are also dark regions in the Universe
that we can't see, but we can detect them.
In these regions the force of gravitational attraction
is so great that not even light can escape:
they are Black Holes!

NARRATOR (O.S.)

Stellar Black Holes originate
when a large star,
much more massive than our Sun, reaches the end of its life
and explodes as a Supernova.
At the centre of most galaxies, including the Milky Way,
there are supermassive Black Holes
which play an essential role in the formation and evolution of
galaxies.

NARRATOR (O.S.)

If they don't let light escape, how do we detect them?
From their gravitational influence
on the neighbouring stars that we *can* see,
from the radiation emitted by the matter
that is being swallowed up by them
and from the enormous deformation of space-time
which deflects the light from other more distant stars.

SEQUENCE 17: EVENT HORIZON.

NARRATOR (O.S.)

We live in a Universe of light...

NARRATOR (O.S.)

Over the course of our history

we have managed to "tame" it.

We have gone from using torches

to using light in a whole range of things,

not just to illuminate a space...

NARRATOR (O.S.)

...we fill our lives with lights

which accompany us in everything we build...

NARRATOR (O.S.)

...in the things we investigate...

NARRATOR (O.S.)

...in the search for solutions inspired

by nature...

NARRATOR (O.S.)

... in improving our health...

NARRATOR (O.S.)

... We play with it to create works of art,

to put on shows,

to screen images in films.

We are doing so right now, here in the Planetarium...

And the most exciting thing of all is that

it continues to surprise us.

We are almost constantly finding

new properties and applications of light...

CHILD (O.S.)

Hey, mum!

CHILD

Maybe one day I could study something

to do with light...

MOTHER

If that's what you'd like, great...

CHILD

Fireworks are really cool!

MOTHER

Yes, they're beautiful,

but we must be very careful not to misuse them,

and light in general...

NARRATOR (O.S.)

By doing so we'll preserve the darkness of our skies,

helping to conserve animal and plant biodiversity.

We'll save energy and make a big contribution

to keeping this planet the way we found it

tens of thousands of years ago.