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Mysteries of the Unseen World

By Mose Richards

For those who
stretch their imaginations,
who envision a future
where technology
serves the greater good...
their mission is our mission.
At Lockheed Martin,
we never forget
who we're working for.
Looks like an ordinary city.
We know what we'll see
on these streets, inside these walls.
Or so we think.
The people living
in this apartment building
are surrounded by things
they can't see.
All of us are.
Everywhere.
Things too slow
for our eyes to detect...
or too fast to follow.
By things that can be seen
only through light waves
invisible to us.
Bye, Mom.
Have fun.
A day in their lives
would look a lot different
if they could see all
the light waves around them.
Or see other worlds around us
that are too small...
microscopic...
or smaller yet...
down to the heart
of matter itself.
Imagine if, for one day,
we could see what they can't-
all that's too slow,
too fast, too small...
Or simply invisible.
It would forever
change our understanding

of the planet we live on.
On this day, we'll see beyond
the limits of human vision.
Normally, we see light waves
that bounce off objects.
They beam into our eyes...
and onto our retina
at the back of our eye,
where an upside-down
and backward image appears.
It's turned into electrical impulses
that race to the brain...
which allows us to see
what we need to survive.
But there's a lot we miss.
We only see the rainbow
of light waves called visible light.
But that's just a fraction
of the millions of wavelengths
in the vast
electromagnetic spectrum.
Some of this invisible light
has waves longer
than the rainbow's,
such as infrared...
microwaves...
and radio waves.
Others are shorter,
including ultraviolet...
X- rays...
and gamma.
These waves radiate
from the sun...
space...
From everything around us.
On the rooftop,
there are creatures
that can see
other light waves.
A bee can view the world
through ultraviolet light.
It can see UV markings
on flowers
that guide bees

and other pollinators
right to their pollen.
All of this
is invisible to you.
You just see a bee
feeding on nectar.
Even a mosquito
has an advantage over you.
Through infrared vision,
it can see the heat patterns
on your body.
Warmer spots means more blood
near the surface.
We have cameras
that can see like a mosquito...
revealing what's hot...
and what's not.
The brighter something looks,
the hotter it is.
Some wavelengths can pass
right through objects.
Wonder what's going on inside
the apartment building?
Gamma rays can show you.
With X-ray vision, you could see
an egg hidden within a quail...
the mechanics
of an animal in motion...
and what's going on inside
anyone's body.
Radio waves can also
pass through us.
An MRI can use them,
along with magnetic energy,
to show your heart beating.
The more invisible light waves
we can see,
the more secrets we uncover
about the world around us.
But that's only the beginning.
Some things happen
too slowly for our eyes.
In the 1930s,
an amateur scientist in Chicago

wanted to see how flowers move.
John Nash Ott had the idea
of shooting a single frame of film
at regular intervals...
15 minutes apart.
By projecting the pictures
at the normal speed of movies-
24 frames per second-
Ott saw that flowers move dramatically
as they react to light.
He also had some fun.
We call it
"time-lapse photography,"
and through it,
we discover movement
Where our eyes see none.
We can see how organisms
emerge and grow.
How a vine survives by creeping
from the forest floor
to reach the sunlight.
A passion-flower vine
tosses its tendrils
like a grappling hook,
wrenches itself up,
and throws open
its sun-catching blossom.
We can see
living things decompose...
providing resources that allow
new life to flourish.
Dead matter can be food
for slime molds,
among the simplest life-forms.
Time-lapse shows that they
are constantly on the move.
One slime mold
is astonishingly complex.
When individual cells
run out of food,
they group together
and form stalks
with spores at the top.
The spores can be picked up

by the wind or passersby
and carried to a place
with more food.
Good boy.
On a grander scale,
time-lapse allows us
to see our planet in motion.
We can view not only
the vast sweep of nature...
but the restless movement
of humanity.
Each streaking dot
represents a passenger plane.
By turning air traffic data
into time-lapse imagery,
we can see something
that's above us constantly...
but invisible-
the vast network of air travel
over the United States.
We can do the same thing
with ships at sea-
turn data into a time-lapse view.
Decades of data give us
a view of our entire planet
as a single organism,
sustained by currents
circulating through the sea...
by moisture and warmth,
swirling through the atmosphere,
pulsing with lightning,
adorned by the Aurora Borealis.
It may be the ultimate
time-lapse image-
the anatomy of Earth,
brought to life.
At the other extreme of time,
there are things that happen
too fast for our eyes.
But we have technology
to see that world, too.
Introducing Dr. Harold E. Edgerton
of the Massachusetts
Institute of Technology.

His stroboscope light,
my friends, is really something,
and it's put the 'super'
in super-speed photography.
While normally film runs
through the average movie camera
at 90 feet a minute,
Edgerton's flicker box
can handle 125 feet a second.
In normal speed movies,
a bullet shot from the muzzle
of a high-powered air gun
is invisible.
Now Edgerton really
photographs a bullet in flight.
Watch it come in from the left-.
Here, fascinating patterns
of movement.
And when you recall that
all the action of this bulb smashing
actually took place
in the fraction of a second,
you realize that here is speed
in movie photography, indeed!
High-speed cameras
do the opposite of time-lapse.
They shoot images thousands,
or even millions of times
faster than our vision.
When played back
at 24 images per second...
they show us remarkable
things we normally miss.
When you see drops
hit the water,
here's what you don't see.
Every drop bounces like a ball.
Held together
by surface tension,
it continues to get smaller
and smaller.
This happens every time
a raindrop hits a puddle.
A hundred times every second,

lightning strikes
somewhere on Earth.
Little was known about lightning
till high-speed cameras turned
the research upside down.
Literally.
What our eyes see
is energy flowing downward
from the clouds.
Now we can see
that electricity also moves
upward from the ground.
If we can see lightning bolts...
We can see almost anything
that's lightning-fast.
When a dragonfly flutters by,
you may not realize
it's the greatest flyer in nature.
It can hover...
fly backwards...
and even upside down.
No one knew the secret.
But high speed shows
that a dragonfly can move
all four wings
in different directions
at the same time.
No aircraft can do this.
If we can see how nature's
ingenious devices work...
we can imitate them.
By tracking markers
on an insect's wings,
we can visualize
the airflow they produce.
What we learn could lead us
to new kinds of robotic flyers
that expand our vision
of important events
in remote places.
How many secrets remain
to be discovered
in the super-fast worlds of nature?
We move through

the landscape like giants,
unaware of the wonders
too small for us to see.
Long ago, we noticed
that a glass sphere
made things appear larger.
Grinding it down into a lens
magnified objects even more.
Stacking lenses in a tube
greatly multiplied the effect,
and the compound microscope
was born.
It let us peer into a world
we'd never seen before.
Suddenly, we could see
creatures in common pond water
that we didn't
even know existed.
But there is a limitation
to the compound microscope.
We can't see down
into the scales of the butterfly's wing
because visible light waves
are too big.
Everything smaller
goes out of focus.
We needed a microscope
that used something smaller
than visible light.
The scanning electron microscope
fires electrons,
smaller than atoms,
creating an image
that magnifies things
by as much as a million times.
It shows that deep
inside the tiny scales
of a butterfly's wing
are even smaller structures
which are shaped to reflect
only pure blue light waves,
giving the wings
of a Morpho butterfly
one of the most brilliant blues

in nature.
The electron microscope
reveals things
both bizarre and beautiful.
Guess what this is.
A butterfly egg.
The skin of a shark.
A caterpillar's mouth.
The eye of a fruit fly.
An eggshell.
A tomato stem.
A flea.
A snail's tongue.
We think we know most
of the animal kingdom,
but there may be millions
of tiny species
waiting to be discovered.
Even the air we breathe
is full of unseeable stuff-
pollen...
skin flakes...
insect parts...
animal hairs.
There's even matter from space,
including micro diamonds and jewels
from other planets
and supernova explosions.
30,000 tons of space dust
falls to the Earth every year.
Some of it is
in every breath inhaled
by all the living things on Earth,
including you.
And it gets
even more personal.
There are unseen creatures
living all over your body,
possibly including mites
that spend their entire lives
dwelling on your eyelashes,
crawling with their eight legs
over your skin at night.
They're on some of you...

right now.
When you're unlucky enough
to get a case of head lice,
this is what's living
in your hair.
More than 1,000 strains of bacteria
could be in your belly button.
This is what causes stinky feet.
Some 32 million bacteria
live on your skin,
most of them harmless
or even good for you.
There are far more organisms
living on you
than there are people on Earth.
It turns out that the world
of the really small
is full of clever things
we can use.
The surface of a lotus leaf
repels almost any liquid.
Whoa! That's so cool!
A super-close
look reveals the secret:
tiny hair-like bumps
that cause drops
to roll right off the leaf.
Maybe we could mimic this,
making a coating to shield
airplanes from ice buildup.
Once, it was a mystery
how a gecko could walk up
smooth glass.
Gecko feet are covered
by half a million tiny bristles
that branch into split ends,
each with a pad on the tip.
The structures build up
an electrical charge
that attracts them
to the surface,
adding up to incredible
sticking power
and a model

for a new kind of robot
that could climb
almost anything.
A spider also harbors secrets.
Spider silk thread is,
pound for pound, stronger than steel
and yet completely elastic.
Imagine what we might build
if we could produce
a synthetic version.
The first step is getting
a closer look at spider silk.
The journey could take us
all the way down to what we call
the nanoworld.
The silk is 100 times thinner
than a human hair.
On it, there's bacteria.
Near the bacteria,
ten times smaller, a virus.
Inside that, ten times smaller,
three strands of its DNA.
And nearing the limit
of our most powerful microscopes,
single carbon atoms.
Four of them are the size
of one nanometer.
Welcome to the nanoworld.
This incomprehensibly small
place is the new frontier.
Exploring it will lead
to huge changes in our lives.
Our most advanced microscopes
can now see this:
individual atoms, though fuzzy,
proving years of scientific theory,
simulated here.
And not only can we see them-
with the tip
of a powerful microscope,
we can actually move atoms
and begin to create
amazing nano devices.
Some could one day

patrol your body
for all kinds of diseases,
and clean out clogged arteries
along the way.
Tiny chemical machines
of the future
may even repair DNA.
One of the wildest things
about the nano world,
substances here
behave differently
than the same material
does in our world.
To us,
gold is golden in color.
But nano gold
can be any color.
It absorbs light
and generates heat,
leading to an idea:
injecting nano-sized gold particles
into the bloodstream...
which are chemically coded
to attach to cancerous cells.
An incoming laser beam
heats the gold particles...
burning the cells.
The promise of nano
goes beyond medicine.
Another material
with far different nano properties
is carbon,
the same breakable stuff
found in pencil lead.
At the nano scale,
it has mind-boggling strength.
With it, we've created
the world's thinnest material,
graphene,
one carbon atom thick.
It's harder than diamonds
but nearly
as flexible as rubber.
Turned into a roll,

it's called a carbon nanotube,
one of the strongest
and lightest materials on Earth.
With it, we could
one day make things
we can only dream about today.
It may even be possible
to use carbon nanotubes
to build an elevator to space.
We are on the threshold
of extraordinary advances
born of our drive to see
all that's hidden
in the world around us.
On a summer evening,
under an endless rain
of cosmic dust,
the air full of pollen
and skin flakes
and bits of everything on Earth...
people go about their lives...
Happy birthday.
- Happy birthday.
surrounded by the unseeable.
Knowing there's much more
around us than we can see...
forever changes
our understanding of the world.
Who knows what waits
to be seen...
What new wonders
will transform our lives.
We will just have to see.