

1 Tremendous Earth

The **T**remendous¹ Earth is in my hands
Six **T**rillion **T**rillion kilograms.
And if you think that's **M**assive just **M**easure the sun,
It weighs **M**ore than **M**other Earth times a third of a **M**illion.

It's a masterpiece by the Creator
Forty thousand kilometers at the Equator.
In a second light can go that distance very fast
How many times? 1 2 3 4 5 6 7 and a half.²

Continental drift in Southern Asia
Pushed Everest to the top of the Himalayas
Highest mountain on Earth, reaching to the sky
Everest is **N**ear **N**ine kilometers high.

Tectonic plates spreading since days of yore
Keep the Dead Sea sinking, more and more.
Fully **F**our hundred meters below sea level
Lowest point on Earth, in Jordan and Israel.

The **T**remendous Earth is in my hands,
Six **T**rillion **T**rillion kilograms.
And if you think that's **M**assive just **M**easure the sun,
It weighs **M**ore than **M**other Earth times a third of a **M**illion

¹ Large letters emphasize the alliteration that helps you remember the lyrics.

² So, light can go around the Equator 7.5 times in a second.

2 Mama's Genes

Cells have cell membranes,
To divide what's in from what's out.³
The membrane lets in food and oxygen
While waste and CO₂ go out.⁴

Mitochondria⁵ take glucose
And use it to make ATP
The ATP loses a phosphate
Giving the cell energy.

The nucleus is like the cell's brain
Exchanging messages in the form of proteins.⁶
And when it's time for the cell to reproduce itself
The nucleus has all the genes.

The genes are like an instruction book.
DNA gives the cell ways and means
To eat and move, reproduce, and die.
It's all controlled by those genes.⁷

Now mama cells give to their children
Half or even all of their genes.
And if it's half, then the other half comes from the daddy
To make a full set of genes.⁸

³ All living organisms are made of one or more cells. Each cell is surrounded by a membrane, in the same way that our body is surrounded by our skin.

⁴ CO₂ is carbon dioxide.

⁵ Your body's cells contain different *organelles*, which perform different functions. These are just like the *organs* in your body (e.g., heart, kidneys, spleen), which perform different functions.

Glucose is a type of sugar, and sugar is a fuel, i.e., it stores energy. Mitochondria are organelles that use the energy stored in glucose to create a useful energy-storing molecule called ATP. The ATP molecules are sent around the cell in order to provide energy for any of the thousands of different functions the cell needs to perform.

How does ATP work? Well, "ATP" stands for adenosine triphosphate, which means an adenosine molecule connected to three phosphates. It takes a lot of energy to attach the last phosphate onto the molecule, and this energy can be used to perform useful work by causing the ATP to pop off one of its phosphates in a controlled manner.

⁶ Proteins are molecules that do most of the work in a cell. Proteins are, in fact, nanomachines. When the nucleus wants a particular function to be performed, the nucleus builds a molecule carrying the instructions to create a protein that can carry out the desired function. The nucleus transports that molecule with the instructions out of the nucleus, where a nanomachine (called a ribosome) takes the molecule and uses it to build the desired protein.

⁷ So how does the nucleus know how to build so many proteins? That is why we have DNA. DNA is a very long molecule, which can be read in order, from start to finish, to include the code for about 20,000 different proteins. The code of the DNA is itself based on only four different molecules (labeled A, T, G, and C). So, the DNA code for a particular protein might be ATTCCTTGATTCGTAATC... A gene is the section of a DNA molecule that carries the code for a particular protein.

⁸ Most of my genes are identical or almost identical to your genes. A baby gets half of its genes from its mother and half of its genes from its father. Bacteria, on the other hand, inherit all of their genes from the "mother."

3 Blood Voyage

HEART! Aorta, arteries, arterioles and capillaries
Capillaries, venules, veins, and the vena cava⁹
Blood goes to the heart and to the lungs
To get O₂ and to dump CO₂.
Back to the HEART!

4 Heart Beat

Right! Right! Right! Right!

Arteries carry blood away!¹⁰
Arteries carry blood away!
'Cause "artery" starts with the letter "A"!
'Cause "artery" starts with the letter "A"!

How many chambers in my heart?
Four chambers in your heart!
Count them! *One! Two!*
Count them! *Three! Four!*
Pumping the blood around my body
One, two, THREE FOUR!¹¹

Your right atrium, your right ventricle,
And then your lungs!
Your left atrium, your left ventricle,
Then all around you!

⁹ This song tracks the path of blood through the various blood vessels. Blood leaves the heart through the aorta, which is the biggest artery in the body. Then, the aorta branches into smaller arteries, which in turn branch into arterioles (very small arteries).

After the arterioles, blood enters the capillaries, which are tiny, and which have thin walls that allow oxygen to pass out of the capillaries in order to supply oxygen to all of the tissues of your body. The thin capillary walls also allow the waste product carbon dioxide to enter the bloodstream from the body's tissues.

After the capillaries, blood goes into venules (very small veins). The venules merge into veins, which in turn merge into the biggest vein in the body – the vena cava. The vena cava empties into the heart, which pumps the deoxygenated blood to the lungs to get oxygenated. Oxygenated blood comes back from the lungs to the heart, where it gets pumped out again through the aorta...

¹⁰ Arteries carry blood away from the heart.

¹¹ Your heart has four chambers. Deoxygenated blood enters from the vena cava into the right atrium, passes to the right ventricle, and is then pumped to the lungs. In the lungs, the blood gets oxygen and dumps carbon dioxide. The blood returns from the lungs into the left atrium, from which it passes into the left ventricle. The left ventricle gives a big squeeze and pumps the blood to the rest of the body.

Old blood goes toward the heart in veins!
Old blood goes toward the heart in veins!
Then to the lungs to get some oxygen!
Then to the lungs to get some oxygen!

Carotid arteries carry blood to the brain!
Carotid arteries carry blood to the brain!
And it comes back down in the jugular veins!
And it comes back down in the jugular veins!

5 Digestion - Uncensored

Mouth, pharynx and esophagus
Then food goes to your stomach
To the small intestine
The large intestine
The rectum and out the anus.

The stomach and the small intestine
Digest the food
Passing through to the blood
Nutrients that are good.¹²

The large intestine waits,
To receive the waste,
And it stores it until I defecate.

¹² That is, the blood gets all of the (good) nutrients in the food and takes them away to distribute them in the rest of the body. Unfortunately, unhealthy things in the food, such as saturated fats and toxins (poisons), are also taken by the blood to the rest of the body.

6 Neurons In G (with apologies to Bach)

Neurons are my nerve cells.
Axons are my nerve fibers.
Axons carry signals from neuron to neuron.

Sometimes a motor neuron tells
A muscle that it's time to contract.
That is how my brain and spinal cord
Control my body.

Sensations like
Smell, taste and sight
Reach my brain through the cranial nerves.
But to and from my head the signals go
In my spinal cord.

7 Cranial Cabaret

Twelve¹³ pairs of cranial nerves
One's Olfactory.¹⁴
Two is the Optic nerve,¹⁵ and
Three: Oculomotor¹⁶

Four is the Trochlear nerve and
Five: Trigeminal.
Six is the Abducens, and
Seven: Facial.

Eight: Vestibulocochlear,¹⁷ and
Nine: Glossopharyngeal.
Ten is the Vagus
Eleven: Accessory and
Twelve: Hypoglossal¹⁸

¹³ The cranial nerves are often referred to by their number rather than name.

¹⁴ Olfactory is for smelling.

¹⁵ The optic nerve carries signals representing what you see to the brain.

¹⁶ The oculomotor nerve moves the eye (*oculo* = eye; *motor* = move).

¹⁷ The vestibulocochlear nerves carries sound signals, and is responsible for your balance.

¹⁸ The last four cranial nerves (glossopharyngeal, vagus, accessory, and hypoglossal) control or receive information from the tongue, mouth and throat. (*hypo* = under; *glosso* = tongue; *pharyngeal* = pharynx/throat.) The vagus also sends commands to and receives information from your heart, stomach, and other organs.

Twelve pairs of cranial nerves
 Link my brain to the rest of my head
 For functions like chewing and hearing
 Seeing and swallowing.

8 Brains!

Brains!
 Have two hemispheres, called my cerebrum --
 White inside, gray outside of my cerebrum.
 Gray matter's also called the cerebral cortex
 That's where I do my thinking!
 Cerebral cortex, that's where I do my thinking!
 My cerebellum sits by my brainstem.
 My cerebellum sits by my brainstem.

*When I went to school, I could never remember that $e = 2.7182818$.
 You all know the rest, 'cause you know this song.
 It's easy! Just follow the notes with me. Do re me is 1, 2, 3.¹⁹
 And to remember 1.4142135, you know, the square root of two?²⁰
 Just use your...*

Brains!
 My right hemisphere is right holistic.
 And my left is left for mathematics.²¹
 Corpus callosum²² spans the two
 And my limbic system helps control my emotions
 Aaaaargh! My limbic system helps control my emotions!
 And basal²³ ganglia give good posture.
 Yeah, basal ganglia give good posture.

¹⁹ “e” is an important number in all areas of math, just like pi. If you listen to the flute in the interlude portion of Brains, you’ll learn the first 23 digits of e (namely, 2.71828182 845 904 523 536 02). The digits 1 through 8 correspond to middle-C through high-C. B-flat below middle C is 0, and high-D is 9. (The song itself is in B-flat, so it has B-flat and E-flat.)

²⁰ Similarly, Brains teaches you the first 51 digits of the square root of 2 (namely, 1.41421 35 623 730950488 01 68872420 969807856967 187537694). This song is also roughly in B-flat, although the first E is an E-natural. The notes of the square root of 2 from the main melody of Brains, i.e., the words “Brains have two hemispheres” are sung to 1.41421. The initial guitar solo in Brains is precisely these digits of the square root of 2.

²¹ The divisions between the left and right hemispheres are to some extent generalizations.

²² The corpus callosum is a bundle of axons that carries information between the two hemispheres.

²³ The basal ganglia (or basal nuclei) are a group of nuclei in the brain interconnected with the cerebral cortex, thalamus and brainstem. Mammalian basal ganglia are associated with a variety of functions: motor control, cognition, emotions, and learning.

9 Brains Doowap

Frontal, Parietal, Temporal, Occipital
Frontal, Parietal, Temporal, Occipital
Frontal, Parietal, Temporal, Occipital lobes

Oh, my **F**rontal lobe
Has my **F**unny personality.
It moves my body where I want it to be.
Oh, my frontal lobe
By my Forehead near the front of my head.

Oh, my **P**arietal lobe,
Feels **P**ain and touch and tickling
And hot and cold and in-between.
Oh, my parietal lobe
Where a **P**irate holds the top of his head.

Frontal, Parietal, Temporal, Occipital
Frontal, Parietal, Temporal, Occipital
Frontal, Parietal, Temporal, Occipital lobes

Oh, my **T**emporal lobe,
Attempts to understand the words that I hear,
Helps me speak to people far and near
Oh, my temporal lobe,
Sitting in my head right by my ear

Oh, my **O**ccipital lobe,
Lets me see an **Ox**, and he sees me
'Cause together, we both see
In our occipital lobes,
*Like an **Ox** in a box at the back of the brain.*

Frontal, Parietal, Temporal, Occipital
Frontal, Parietal, Temporal, Occipital
Frontal, Parietal, Temporal, Occipital lobes

10 March to the Loo

The kidneys take out toxins and water from the blood.
This mixture is what we call urine.

The urine leaves the kidneys through the ureters
Which are two tubes that lead to the bladder.

And when it's time to pee go to the lavatory
And don't forget to shut the door!

'Cause when you've got to go
Your bladder lets you know
It'll let the urine flow out through the urethra.

11 Spleen Lullaby

The spleen is an organ
Which starts every mornin'
Taking out old red blood cells from
The circulation.

It works in the daytime
And also at night
Taking out old red blood cells,
"Erythrocytes."

Day and night,
Old erythrocytes
Are grabbed by the spleen
And then disintegrated.
While in the marrow
Of bones long and narrow,
New blood cells are made for
Today and tomorrow.

12 Papa's Boots (Teeth)

I've four incisors in the middle of the top row.
Four on the bottom, sharp as Papa's knives.
They are all flanked by my pointy canines.
Four little daggers that help me dine.

Next to my canines are my premolars.
They're called bicuspids, 'cause they've got two roots.
In back of my mouth, my broad flat molars...
They're rough and tough, yeah, like Papa's boots.

Thirty two teeth... cutting, tearing, grinding.
I'm proud of them, my pearly whites.
My Papa told me to take good care of them
And keep them twinkling into the night.

13 If You're Bony and You Know It

Phalanges, carpals, metacarpals, clap your hands!
Phalanges, carpals, metacarpals, clap your hands!
Phalanges, carpals, metacarpals in your fingers, wrist, and palms²⁴
Phalanges, carpals, metacarpals, clap your hands!

Phalanges, tarsals, metatarsals, stomp your feet!
Phalanges tarsals, metatarsals, stomp your feet!
Phalanges, tarsals, metatarsals in your toes, heels and soles²⁵
Phalanges, tarsals, metatarsals, stomp your feet!

The maxilla and the mandible say, "Hello!"
The maxilla and the mandible say, "Hello!"
The maxilla²⁶ is above and the mandible below.
The maxilla and the mandible say, "Hello!"

Seven cervical vertebrae are in your neck
Seven cervical vertebrae are in your neck.
Seven cervical vertebrae, there is one for every day
Seven cervical vertebrae are in your neck.

²⁴ The phalanges in your hand are the finger bones. Carpals are little roundish wrist bones. Metacarpals come in-between, i.e., they are in your palms.

²⁵ The phalanges in your feet are your toe bones. The tarsals are little roundish ankle bones. Metatarsals come in-between, i.e., they are the bones in the sole of your feet.

²⁶ The maxilla is the bone holding your upper set of teeth, and the mandible is the lower jaw bone.

Coccyx²⁷, ilium and sacrum in your hips!
Coccyx, ilium and sacrum in your hips!
Coccyx, ilium and sacrum, let me see you shake 'em
Coccyx, ilium and sacrum in your hips.

14 Skeleton Story

Three types of bones are in my hand.
The fingers are the phalanges.
The wrist has marbles, called the carpals
Metacarpals in-between.

Two long bones are in my forearm
The radius above the thumb
The ulna is so long and dinky
Ulna sits atop my pinky.

Above my elbow is the funny bone.
It's also called the humerus.
In fact it is quite humorous
That I do not know why that is.

My shoulder blade's the scapula.
Each one looks like a spatula.
Below my neck it's magical
Those magic bones are clavicles.

My chest bone's made of three bones
And later on I'll learn 'em.
The most important one of all's
The middle one -- the sternum.

My ribs branch off the sternum
And then go off to play.
They run around behind my back
And meet my vertebrae.

²⁷ The sacrum is the middle bone of the hip, the coccyx is where your tail would be (if you had a tail), and the ilium is like the wing of the hip.

At the bottom of the spine we make room
For the fused bone called the sacrum.
We all have tails, just like foxes
But our tail is the coccyx.

When a lemur cooks his vegetables
He puts them in a steamer.
When I want to touch my top leg bone
I reach down for my femur.

The Prince got down on one knee
To propose to Cinderella.
He put his weight on his knee-cap.
His knee-cap's the patella.

Cinderella's daughters
Play soccer down in Libya.
They sometimes bruise their shinbones.
The shinbone is the tibia.

If you fib you lie to Mama
If you fib you lie to Papa
My fibula's below my knee
By the tibia it stands you see.

The postman brings me parcels.
His heel bones are his tarsals.
His metatarsals (if you please)
Reach his toes the phalanges!

What about the three little bones in our ears?

Oh, I have a song about that...

Oh, the eardrum hits the malleus
And the malleus hits the incus
And the incus hits the stapes:
Boom Boom Boom!

15 Don't Take My Breath Away

When my diaphragm goes down²⁸
The air goes into my nose and mouth.
...Then where is it found?
First in the **Ph**arynx that **L**eads to the **L**arynx,
The voice box that lets me talk to my parents.

Then the trachea²⁹ takes air to the lungs.
Each lung is like an air-filled sponge.

The sponge has bumps that you and I
Will learn to call alveoli.³⁰

Oxygen leaves alveoli
And into what they're surrounded by...
Capillaries, capillaries, carrying blood
And that's how oxygen gets to the blood.

16 Metabolism (with deep apologies to Bizet. Really.)

Living cells burn fuel
A fire does the same
This process mixes
Fuel and oxygen,

...Releasing
Energy from chemical bonds
Plus water and carbon dioxide!

This is called “metabolism”
In living cells,
“Combustion” by a fire.

²⁸ We have a muscle called the diaphragm, which is a flat muscle under our ribcage. When the diaphragm contracts, it goes down, causing the lungs to expand. When the lungs expand, air rushes in. (Read the “thoracic diaphragm” article on Wikipedia for a more detailed explanation.)

²⁹ After your nose or mouth, air goes to the pharynx and larynx, which are in the back of your throat and neck. Then, the air goes into the trachea (windpipe).

³⁰ We have hundreds of millions of alveoli in our lungs. The alveoli are tiny sacs, and inhaled air goes into the alveoli. Capillaries are the smallest blood vessels, and these surround the alveoli. When we inhale, the oxygen in the air reaches the alveoli, and passes through the walls of the alveoli to enter the blood flowing in the capillaries. That's how oxygen gets to the blood. (Simultaneously, carbon dioxide in our blood passes out of the capillaries and into the alveoli. When we exhale, the carbon dioxide is thus removed from our body.)

17 Sunlight on my Branches

Green plants use photosynthesis
To take carbon dioxide
And react it with water
This is powered by sunlight.

This reaction makes sugar³¹
Which the plant will need
And also oxygen
Which plants and animals breathe.

Sunlight lets this process begin
Where the inputs and outputs of metabolism
Are the outputs and inputs of photosynthesis
This is the cycle of life, and now I know what it is.

18 Condensation Canon

Condensation takes water
Vapor from humid air.
Droplets form on a cool surface,
Raising its temperature.³²

³¹ Note that sugar, like oil, is a hydrocarbon fuel. Photosynthesis uses the sun's energy to combine water with carbon dioxide and thereby make fuel. By contrast, a fire breaks down fuel into carbon dioxide and water, releasing energy.

Water vapor that naturally condenses on cold surfaces into liquid water is called dew. Water vapor will only condense onto another surface when the temperature of that surface is cooler than the temperature of the water vapor. The water molecule brings a parcel of heat with it. When water vapor condenses into liquid water, hydrogen bonds form and release heat, which causes the air temperature to rise. Heat is removed from the air and the temperature drops when evaporation is occurs.

19 Pop! Goes the Molecule

Evaporation cools me off,
Whenever I perspire.
The molecules all shake and move, ...till
POP! goes the molecule.

Water will evaporate,
Cooling what it leaves.
The molecules³³ all shake and move, ...till
POP! goes the molecule.

The wind blows by, the atoms vibrate,
Till one has enough energy...
The molecules all shake and move, ...till
POP! goes the molecule.

Water will evaporate,
Cooling what it leaves.
The molecules all shake and move, ...till
POP! goes the molecule.

³³ We are discussing molecules of water, which move back and forth, slamming into each other. If a particular molecule of water moves fast enough, it will overcome the forces that attract it to the other water molecules, and then it will shoot away from the surface (e.g., away from your skin). As a result, since this high energy molecule is no longer on the surface, the average speed (energy) of all of the remaining molecules is lower. Temperature is simply a measure of the average speed of the molecules where you are measuring temperature. Since the highest energy molecules fly away from a surface, the average energy of the remaining molecules is lower, and the temperature therefore decreases.

And that, sweet children, is why we sweat when we exercise. Water from inside our body goes onto our skin in the form of sweat. As the sweat evaporates, the sweat remaining on our skin cools off.

20 The Ballad of the Up-the-Quark Brothers³⁴

When two Up-the-Quark brothers come to town,
 They look for their cousin Down-the-Quark all around!
 When they find him he's smilin' ear to ear
 They all shake hands and disappear
 Leaving just a **P**retty **P**roton
 From two Ups and a Down.

The subatomic particles are made of smaller parts
 And if you listen to this song, you'll know them off by heart
 These building blocks are called the quarks, they're in the nucleus bound
 And a proton's made of two Ups and a Down.

21 Charming Quarks

Six Quarks are Up, Down, Charm and Strange,
 Top and Bottom!³⁵
 Six Quarks are Up, Down, Charm and Strange,
 Top and Bottom!

With a "Quark Quark" here,
 And a "Quark Quark" there,
 Here a "Quark," there a "Quark,"
 Everywhere a "Quark"
 Six Quarks are Up, Down, Charm and Strange,
 Top and Bottom!

Mix in a cup, a Down Down Up
 Make a **N**ew thing called a **N**eutron.³⁶
 Mix in a cup, a Down Down Up
 Make a **N**ew thing called a **N**eutron.

With a "Neu- Neu-" here
 And a "Neu- Neu-" there
 Here a Neu- there a -tron
 Everywhere a Neutron!

³⁴ Physicists have shown that protons and neutrons are themselves made of smaller particles, called quarks. Quarks have funny names, as we'll hear in the next song. Two of the quarks are named "Up" and "Down." In this song, we see that a proton is made of two Ups and a Down.

³⁵ Yes – believe it or not, these are the names of the fundamental particles of the Universe.

³⁶ A neutron is made of two Down quarks and an Up quark (that's why you mixed in a cup a down-down-up).

22 Oh when the Atoms³⁷

A negative electron spins
It spins around the nucleus
The nucleus has protons and neutrons
An atom's center is the nucleus.

A **P**roton has a **P**ositive charge
And an atomic weight of one
When I want the atomic number
I count all the protons.

A **n**eutron has a **n**eutral charge
That means it doesn't have a charge
A neutron weighs as much as a proton
Its atomic weight is one.

³⁷ Everything we can see is made of atoms. Every atom has a central portion called the nucleus, which has protons and neutrons inside. We name atoms based on the number of protons that are in the nucleus. Thus, for example, hydrogen atoms have one proton, carbon atoms have six protons, and oxygen atoms have eight protons. (We also say that the *atomic number* of hydrogen is one, etc.)

Electrons spin around the nucleus, like planets going around the sun.

Protons have a **p**ositive charge. This is analogous to (but not the same thing as) the north pole on a magnet.

Electrons have a negative charge, which is like the south pole on a magnet. Therefore, protons and electrons attract each other. Similarly, protons repel protons, and electrons repel electrons.

Neutrons are **n**eutral. That means that they have no charge.

23 Spectrum

Red, orange, yellow, green
Yellow green!
Red, orange, yellow, green
Yellow green!
Blue, indigo and violet can be seen
Red, orange, yellow, green
Yellow green!

Infrared is very hot
Very hot!
Should I touch it?
You should not!
You should not!
Can I see infra red?
You cannot!
Infrared is very hot
Very hot!

Ultraviolet burns my skin
Burns my skin!
It breaks down my collagen³⁸
Collagen!
So, I make more melanin.
Ultraviolet burns my skin
Burns my skin!

³⁸ Collagen is a protein. Tough bundles of collagen fibers support your skin and other tissues. Collagen is very strong, but when it breaks down, your skin wrinkles.

24 Electromagnetic Bandstand³⁹

Microwaves help me cook my meat.
Microwaves are as big as a baby's feet.⁴⁰

While I eat the food, I hear FM radio.
The FM radio waves go from the ceiling to your toe!⁴¹

I burned my toe on infrared coming from the heater.
Infrared waves are a hundredth of a millimeter.

The doctor saw my toe; it was red-orange-yellow-and-green.
These colors are about half of a micron⁴² and all of them can be seen!

25 Ain't Gonna Burn No More

Oh, a fire needs heat⁴³ and fuel.
Heat, fuel, and oxygen.
Heat, fuel, and oxygen.
Heat, fuel, and oxygen.
Oh, a fire needs heat and fuel.
Heat, fuel, and oxygen,
In order to survive.

Oh, the fuel burns in the oxygen,
Making carbon dioxide;
Making steam⁴⁴ and lots of heat;
Making flames that are really neat!
Oh, the fuel burns in the oxygen,
Making carbon dioxide;
Making flame and steam and heat.

³⁹ Light includes the colors we can see, as well as colors we cannot see (but which some animals can see). Some "colors" --like microwaves and x-rays-- cannot be seen by animals either. Visible light and invisible light are both forms of energy that travel in pulses. The distance between each pulse of energy and the next is called its wavelength. This song teaches us what the wavelengths of different common forms of visible and invisible light are.

⁴⁰ About 12 cm

⁴¹ AM radio waves are much bigger... 300 meters!

⁴² A micron is one thousandth of a millimeter.

⁴³ Yes, this is not a mistake. A fire does need heat in order to survive. To demonstrate this, blow body-temperature air on a match, moving all of the heat away from it, and the match will go out.

⁴⁴ Yes, a fire also makes steam. Fuel + Oxygen → Steam + Carbon Dioxide + Heat (energy). Note that in reverse, this describes photosynthesis by green plants, i.e., water + CO₂ + energy (sunlight) → sugar (which is fuel for the plant and which the plant uses for its own needs) + oxygen (simply a by-product, as far as the plant is concerned).

Oh, if you take away the fire's heat,
Or fuel or oxygen
Or fuel or oxygen
Or fuel or oxygen
Oh, if you take away the fire's heat,
Or fuel or oxygen,
It won't burn anymore.

So don't you take away that fire's heat
Or fuel or oxygen
Or fuel or oxygen
Or fuel or oxygen
So don't you take away that fire's heat
Or fuel or oxygen
Or it won't burn anymore.

26 Planet Q&A

The fastest planet is Mercury.
The brightest one is Venus.
We live on Earth.
The red planet is Mars.

The biggest one is Jupiter,
which has rings just like Saturn.
There are rings around Uranus
and Neptune.

Smaller than these is Pluto
About the size of our moon.
In fact it doesn't even
Belong in this tune.⁴⁵

⁴⁵ Scientists used to call Pluto a planet, but in 2006 it was designated a "dwarf planet." (In fact, Pluto is the second largest dwarf planet. Eris is the largest dwarf planet in the solar system, and is further from the Sun than Pluto.)

27 Old Sol

The Sun makes heat by fusion⁴⁶
Turning hydrogen to helium.
Fusion powers all the stars
Turning hydrogen to helium.

The Sun sends light and it takes eight minutes
For the Earth to feel the rays
It's a long, long journey, if you're going
A hundred fifty million kilometers away.

The Sun makes heat by fusion
Turning hydrogen to helium.
Fusion powers all the stars
Turning hydrogen to helium.

The planets spin around it, says Copernicus
Mercury, Venus, Earth, Mars
Jupiter, Saturn, Uranus, Neptune
Spinning around our star.

The Sun makes heat by fusion
Turning hydrogen to helium.
Fusion powers all the stars
Turning hydrogen to helium.

The Sun's nearest sister is Alpha Centauri
She's our neighboring star.
Alpha Centauri's four light years far
Away from the Sun.

The Sun makes heat by fusion
Turning hydrogen to helium.
Fusion powers all the stars
Turning hydrogen to helium.

⁴⁶ In the process of fusion, two hydrogen atoms slam into each other, causing them to fuse together, making a helium atom. This fusion process releases energy in the form of heat and light.

28 Far Away on the Moon

Oh, I wish I could walk on the moon
Four hundred thousand kilometers away
Far away! Far away!
On the moon.

I'd run and jump while on the moon
'Cause I would weigh a sixth of what I weigh today
Far away! Far away!
On the moon.

The footprints of twelve astronauts are on the moon.
The first one's name was Neil Armstrong⁴⁷
Who walked in nineteen sixty nine
On the twentieth of July, of 1969
On the twentieth of July, of 1969!

29 Dinosaur Playground

Two hundred million years ago⁴⁸
Dinosaurs started to walk around.
Then sixty five million years ago
They all fall down!⁴⁹

Triassic, Jurassic, then the Cretaceous⁵⁰
Then the dinosaurs all fall down!

Two hundred million years ago
Dinosaurs started to jump around.
Then sixty five million years ago
They all fall down!

Mesozoic Era, Mesozoic Era
Then the dinosaurs all fall down!

⁴⁷ The second man to walk on the Moon was Ed (Buzz) Aldrin. Michael Collins remained in orbit around the Moon while Neil and Buzz walked on the Moon.

⁴⁸ Actually, dinosaurs started closer to 230 million years ago.

⁴⁹ Most scientists think that the dinosaurs died because a large asteroid struck the Earth about 65 million years ago. (Note that some dinosaurs lived through this period, and their descendants are today's birds.)

⁵⁰ The dinosaurs lived during a time we call the Mesozoic Era. The Mesozoic Era is divided into three different periods: the Triassic Period, the Jurassic Period, and the Cretaceous Period.

30 Mother Russia

Russia⁵¹, Norway, and Finland
Estonia, and Latvia.
Belarus and the Ukraine
Moldova, Moldova!

Black Sea, Georgia
Armenia, Armenia
Azerbaijan, Caspian Sea
Kazakhstan.

All the countries bordering Russia and of the former Soviet Union

Turkmenistan, Turkmenistan
Uzbekistan, Uzbekistan!
Beyond this is Tajikistan
Tajikistan!

Kyrgyzstan, Kyrgyzstan
China and Mongolia
China, North Korea
South Korea, South Korea

31 Southeast Asia Blues

Woke up this morning, feeling dazed and confused
What's in Southeast Asia, it's always in the news
Opened up my atlas, and now I've got the Southeast Asia Blues

Starting in Myanmar
And travelling east to Thailand
Then on to Laos
Campuchea, Vietnam
Across the sea to Malaysia
And to little Brunei
Indonesian Islands
And then the Philippines
East Timor then Oceania:
Papua New Guinea, Australia, New Zealand
And way up north to Japan⁵²

⁵¹ This song is a little more complicated. The countries listed are all of the countries in the former USSR, and those which border Russia (except South Korea, which is included for completeness). The order of the countries goes from Russia to Norway, then counter-clockwise around Russia. Countries whose names are repeated are separated from Russia by another country. Tajikistan, whose name is supplemented with the words "beyond this is..." is even further. Look at a map.

32 South Asia Gayaki

Join me in singing the countries of South Asia⁵³
Now we are singing the countries of South Asia
Afghanistan, Pakistan and India
Nepal, Bhutan and Bangladesh
And the Maldives and Sri Lanka

33 On the Border of Africa

Forty countries on the outside
Of Africa
Egypt⁵⁴ and Libya
Tunisia and Algeria.

Then comes Morocco
Canary Islands
Western Sahara, Mauritania
And the Cape Verde Islands.

Senegal, Gambia, and Guinea-Bissau
Guinea, Sierra Leone
Then Liberia and Ivory Coast
Ghana, Togo and Benin.

Nigeria, Cameroon, Equatorial Guinea
Isles of San Tome and Principe
Gabon, Congo
Cabinda, D.R. Congo⁵⁵
Angola, Namibia

South Africa, Mozambique
And then four islands:
Madagascar, Mauritius, Comoros and Seychelles.⁵⁶

⁵² Japan is not in Southeast Asia, but we decided to include it in this song anyway.

⁵³ We are starting west with Afghanistan and travelling east. The Maldives and Sri Lanka are west and east of the southern tip of India. Go look at a map!

⁵⁴ Going counter-clockwise around the sea-bordering countries of Africa.

⁵⁵ D.R. Congo = Democratic Republic of the Congo (formerly Zaire).

⁵⁶ These are four islands off the east coast of Africa.

Tanzania and Kenya,
Somalia.
Djibouti and Eritrea
Sudan that's Africa!

34 Internal Africa

Inside of Africa, Burkina Faso⁵⁷
Mali, Niger, Chad
Ethiopia
Central African Republic
And Uganda.

Rwanda, Burundi, Zambia
Malawi, Zimbabwe, Botswana
Lesotho, Swaziland
That's Africa.

35 The Middle East - Still Waiting

Clockwise round Israel, all around Israel:
Egypt, the sea⁵⁸ Lebanon
Syria and Jordan

Around Saudi Arabia:
Jordan, Iraq, Kuwait, Bahrain and Qatar
UAE⁵⁹, Oman, Yemen
And above Iraq are Turkey and Iran

⁵⁷ This song includes all of the African countries having no border on the sea. The countries are sung as we move generally from west to east and south.

⁵⁸ The Mediterranean

⁵⁹ UAE = United Arab Emirates

36 Winning Vision (Southern Europe)

Portugal⁶⁰ and Spain
France and Andorra
Monaco, Italy
And the island of Malta
San Marino, Vatican City
Slovenia, Croatia
Bosnia, Herzegovina
Montenegro and Serbia
Albania, Macedonia
Bulgaria and Greece
Leaving Turkey and Cyprus
Southern Europe wishing you peace!

37 Transform! (Eastern Europe)

Estonia⁶¹ and Latvia
Then comes Lithuania
Poland and Slovakia
And then the Czech Republic
Hungary, Slovenia
Romania, Bulgaria
Leaving us Albania
All in Eastern Europe

38 Beer Hall (Western Europe)⁶²

Germany, Austria, Lichtenstein and Switzerland
Monaco, France and Luxembourg, Belgium and Netherlands
To the west, across the water, in the sea stand two islands
The larger one is the UK⁶³ and the smaller Ireland

⁶⁰ Starting west in Portugal and traveling east to Cyprus. Bon Voyage.

⁶¹ We start north in Estonia and travel south in order down to Albania. Enjoy.

⁶² All the countries are sung clockwise around Germany, starting with Austria at 4 o'clock. Apologies to Western Europe – there is less fighting there than in many parts of the rest of the world (you gotta hear the whole song to understand this footnote). Sigh.

⁶³ The UK is the United Kingdom, including England, Scotland and Wales.

39 Scandinavia (Northern Europe)⁶⁴

Reykjavic, Iceland⁶⁵
Oslo is in Norway
Stockholm is in Sweden
Helsinki in Finland
North of Germany is Denmark
With Copenhagen
And not forgetting Kalaallit Nunaat Island – Greenland

North of Germany is Denmark
With Copenhagen
Northern Europe countries
They are all Scandinavian

40 Abagoda (South America)

Colombia⁶⁶, Bogota
Venezuela, Caracas
Guyana, Georgetown!

Surinam, Paramaribo
French Guyana, Cayenne
Brazil, Brasilia.

Uruguay, Montevideo,
Argentina, Buenos Aires
Chile, Santiago
Peru, Lima
Ecuador, Quito!

Southwest of Brazil,
Is Bolivia, La Paz and Sucre,⁶⁷
Also there's Paraguay, Asuncion,
Thirteen countries and capitals
Of South America!

⁶⁴ With apologies to Iceland, Norway, Sweden and Finland, this is sung (more or less) to the Danish National Anthem.

⁶⁵ These countries start west with Iceland, travelling through to Finland, and then dropping south to Denmark. Greenland is west of Iceland and under Danish rule.

⁶⁶ Clockwise around South America, starting at Colombia, which borders Central America. We sing the countries and their capitals.

⁶⁷ Bolivia has two capitals.

41 Central America Samba

Central America used to connect North and South America
But the Panama Canal comes in between - it opened in 1914.

Panama⁶⁸ and Costa Rica
Nicaragua and Honduras
El Salvador and Guatemala
Belize and Mexico

42 Beethoven's Ninth

(with groveling apologies to Beethoven. But at least he liked it loud.)

Beethoven's Ninth Symphony
This part is Schiller's "Ode to Joy."
In 1770 Beethoven was a baby boy.

Fifty seven years went by
It was time for him to die.

Beethoven's Ninth Symphony
This part is Schiller's "Ode to Joy."

⁶⁸ Note that the countries are in geographical order, from Panama, which touches South America, to Mexico. (Technically, Mexico is part of North America, but we thought it fit nicely in this song.)