

THE **CARTOON**  
INTRODUCTION TO  
**CLIMATE**  
**CHANGE**

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THE WORLD'S FIRST AND ONLY **STAND-UP ECONOMIST**

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# CHAPTER 1

## INTRODUCTION

**TWO STORIES ARE  
GOING TO DOMINATE  
THE 21ST CENTURY.**



**STORY #1 IS ABOUT ECONOMIC GROWTH, ESPECIALLY IN POOR COUNTRIES IN ASIA AND AFRICA.**



**CAPITALISM AND FREE-MARKET ECONOMICS ARE GOING TO CREATE A LOT OF NEW WEALTH...**



YOU'RE FEELING THE BENEFITS OF WHAT ADAM SMITH CALLED THE **INVISIBLE HAND**.

YOU CAN LEARN MORE ABOUT THAT IN THE **CARTOON INTRODUCTION TO ECONOMICS**.



...AND GIVE MANY MORE PEOPLE THE OPPORTUNITY TO **PURSU**E THEIR DREAMS.



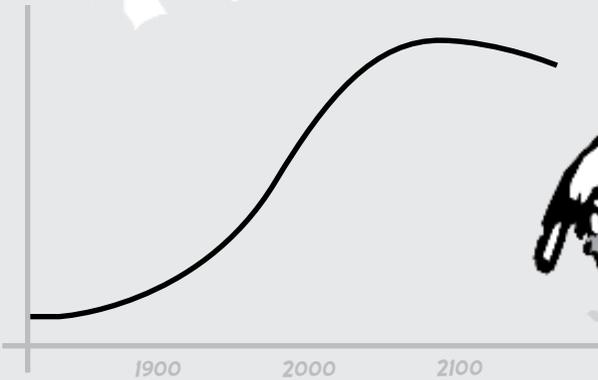
**WEALTHIER FAMILIES  
TEND TO HAVE FEWER CHILDREN...**



HAVING MORE KIDS  
IS **NOT** ONE OF MY  
DREAMS!



... SO THE WORLD POPULATION IS LIKELY TO **PEAK** AT ABOUT  
**10 BILLION** PEOPLE AND THEN SLOWLY DECLINE.



**ENOUGH  
ALREADY!**

AS A RESULT, STORY #1 POINTS IN A DIRECTION  
THAT'S NOTHING SHORT OF **MIRACULOUS**.

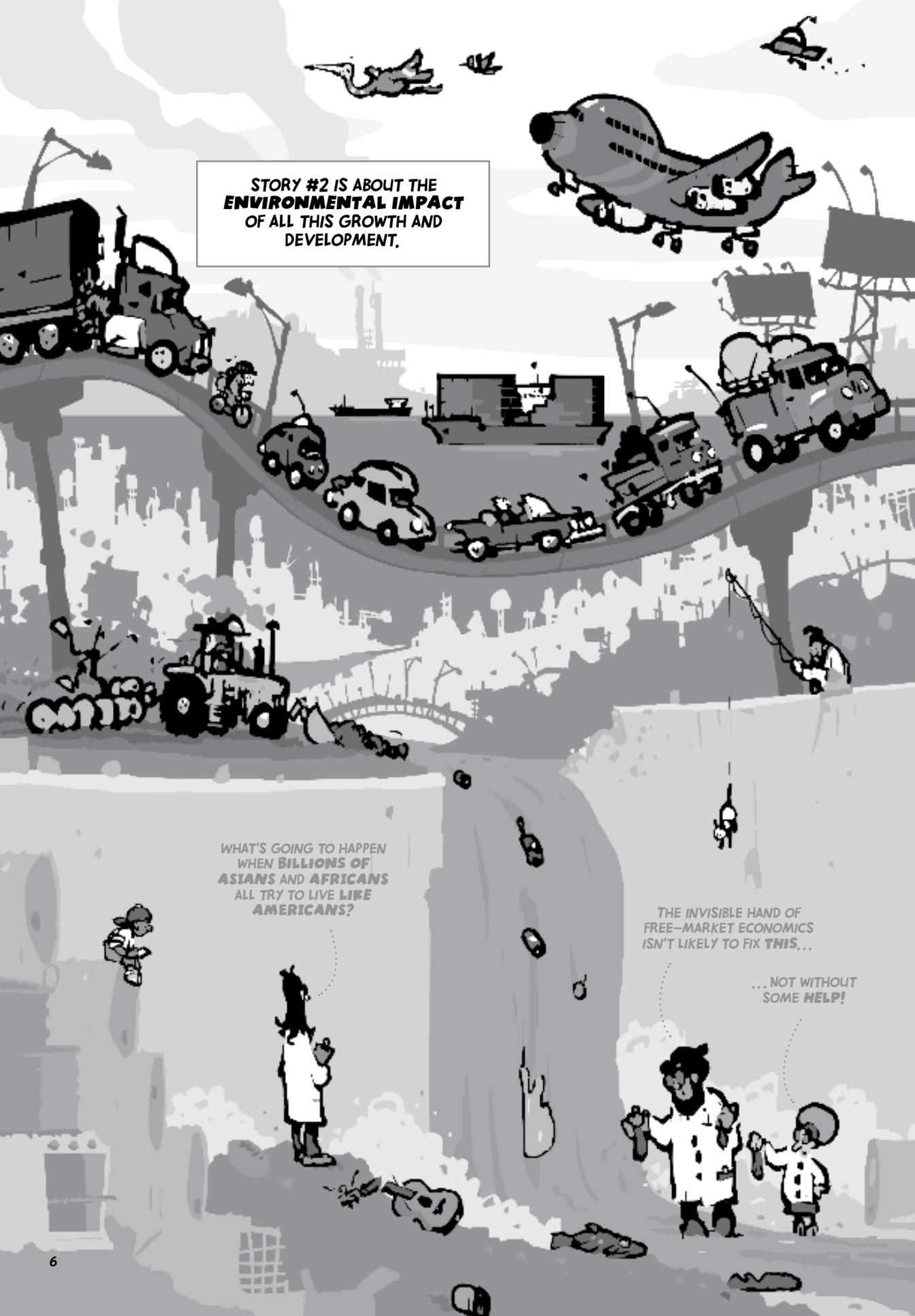


A WORLD OF 2-6 BILLION  
**WELL-EDUCATED** AND  
THEREFORE **HEALTHY** AND  
**WEALTHY** PEOPLE!

IT SEEMS **TOO  
GOOD TO BE  
TRUE!**



**BUT WHAT ABOUT STORY #2?**



**STORY #2 IS ABOUT THE ENVIRONMENTAL IMPACT OF ALL THIS GROWTH AND DEVELOPMENT.**

WHAT'S GOING TO HAPPEN WHEN BILLIONS OF ASIANS AND AFRICANS ALL TRY TO LIVE LIKE AMERICANS?

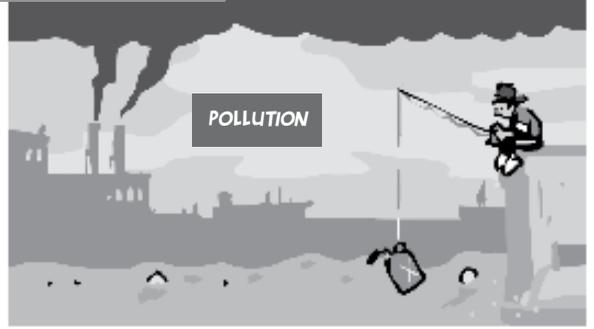
THE INVISIBLE HAND OF FREE-MARKET ECONOMICS ISN'T LIKELY TO FIX THIS...

... NOT WITHOUT SOME HELP!

**ENVIRONMENTAL CONCERNS** COVER ALL SORTS OF TOPICS.



**OVERFISHING**



**POLLUTION**



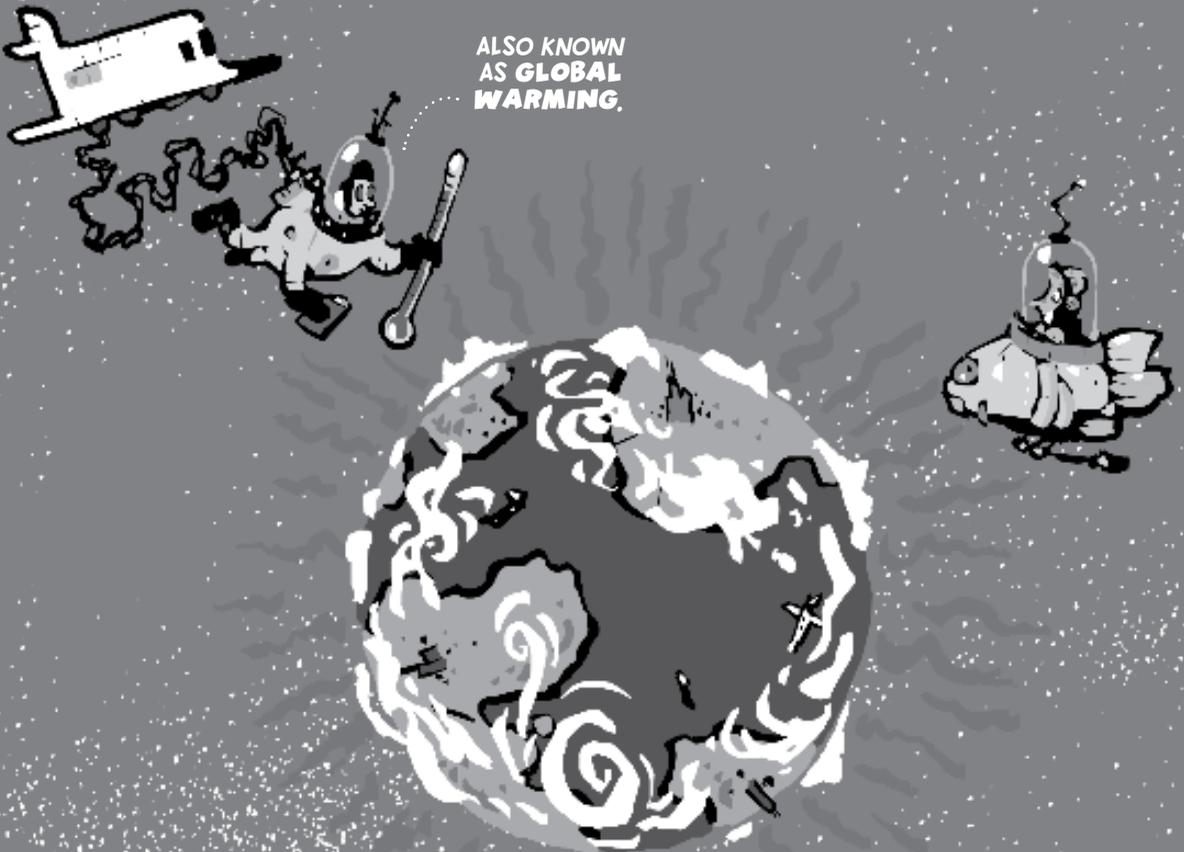
**ENDANGERED SPECIES**



**HABITAT LOSS**

**THIS BOOK FOCUSES ON CLIMATE CHANGE.**

**ALSO KNOWN  
AS GLOBAL  
WARMING.**



**CLIMATE CHANGE IS A POLITICALLY CHARGED ISSUE.**

**YOU'RE A DENIER!**

**YOU'RE AN ALARMIST!**

BROTHER

SISTER

DAD BETWEEN THEM

**BUT IT MIGHT BE POSSIBLE TO FIND SOME COMMON GROUND...**

**THAT COMMON GROUND BETTER BE 6 FEET UNDER BECAUSE WE'RE ALL GOING TO DIE!**

**NONSENSE, WE'RE ALL GOING TO LIVE!**

**...BY THINKING OF CLIMATE CHANGE AS A THREAT.**

THESE ARE ON THE FRIDGE, LIKE MAGNETIC POETRY, BUT MAGNETIC THREATS.

**LIST OF THREATS:**

**VIOLENT VIDEO GAMES**

**NATIONAL DEBT**

**TERRORISM**

**ASTEROIDS**

**BIRD FLU**

**STUPIDITY**

**JUNK FOOD**

**POLLUTED DRINKING WATER.**

**BAD SPEELING**

**POVERTY**

**SPACE ALIENS**

**REALITY T.V.**

HOW DOES THIS ONE COMPARE?

**CLIMATE CHANGE**

MAYBE IT'S AN **EXISTENTIAL THREAT**...

...AND MAYBE IT'S ONLY A **MINOR THREAT**...

CLIMATE CHANGE COULD  
TURN THE EARTH INTO AN  
**ALIEN PLANET.**

HOW DO YOU KNOW IT  
WON'T BE AN **AWESOME**  
ALIEN PLANET?



BROTHER

SISTER

...AND MAYBE IT'LL BE **DECADES** BEFORE WE KNOW FOR SURE,

AND BY THEN IT MIGHT  
BE **TOO LATE TO**  
**DO MORE!**

OR TO DO  
**LESS!**

NO WONDER  
CLIMATE CHANGE IS  
SUCH A **WICKED**  
**PROBLEM.**



THIS BOOK WILL HELP YOU **MAKE UP YOUR OWN MIND.**

AND LEARN **WHAT YOU**  
**CAN DO ABOUT IT...**

...AND WHAT WE CAN  
**ALL DO TOGETHER!**



**YOU MIGHT FIND IT HARD TO BELIEVE THAT HUMANS CAN  
INFLUENCE THE ENTIRE PLANET...**



**... BUT THERE'S LOTS OF SCIENTIFIC EVIDENCE THAT  
HUMAN ACTIVITY IS CHANGING THE CLIMATE.**

**MOSTLY AS A RESULT OF  
BURNING FOSSIL FUELS AND  
DEFORESTATION.**

**AND SOMETIMES BOTH  
AT THE SAME TIME!**

**I THINK IT WILL WORK TO  
KEEP THE HORSE AND THE CAR  
CARRYING TRUCK, BUT AND  
THEN I CAN HAVE THE LOGGER  
IN FRONT OF THE TRUCK  
CHOPPING DOWN A TREE AS IF  
HE'S PAVING THE WAY FOR A  
NEW ROAD.**

**1950s**

**2000s**

**THIS BOOK IS ABOUT THE SCIENCE  
OF CLIMATE CHANGE...**

**PART ONE:  
OBSERVATIONS**

[AKA GLOBAL WARMING ("WANTED" POSTER?)  
OR MAYBE SCIENTISTS SAY "WE SAID THERE'S A  
LOT OF EVIDENCE, AND HERE IT IS!"]

**... AND HOW CLIMATE CHANGE MIGHT  
AFFECT LIFE ON EARTH...**

**PART TWO:  
PREDICTIONS**

**... AND WHAT WE CAN DO  
ABOUT IT.**

**PART THREE:  
ACTIONS**

[SO THE THREE PARTS ARE: WHAT'S  
HAPPENING, HOW BAD WILL IT BE, WHAT CAN  
WE DO ABOUT IT?]

**A GOOD PLACE TO START IS WITH A FEW DEFINITIONS...**

**CLIMATE** REFERS TO WHAT THE WEATHER IN A CERTAIN PLACE IS **USUALLY** LIKE.

SEATTLE IN JULY HAS  
**SUNNY SKIES 90%  
OF THE TIME.**

AFTERNOON HIGHS  
ARE USUALLY 21–28C  
(69–82F)...

... AND IT  
**ALMOST NEVER  
RAINS!**

SOUNDS  
**PERFECT FOR  
A WEDDING!**

**USUALLY** DOESN'T MEAN **ALWAYS**...

... SO YOU SHOULD THINK OF CLIMATE AS  
**AVERAGE WEATHER...**

**SORRY!  
THIS IS VERY  
UNUSUAL.**

**CLIMATE IS LIKE YOUR  
PERSONALITY.**

**WEATHER IS  
LIKE YOUR  
MOOD.**

... AND **CLIMATE CHANGE** AS A **CHANGE IN AVERAGE WEATHER.**

ON AVERAGE,  
THESE FLOWERS NOW  
BLOOM **ONE WEEK  
EARLIER THAN THEY  
DID 50 YEARS AGO.**

**...AND WITH AN *OBSERVATION.***

**EARTH'S CLIMATE  
HAS *ALWAYS*  
BEEN IN FLUX.**

**HERE ON PLANET EARTH,  
CLIMATE CHANGE HAS  
*ALWAYS* BEEN A  
FACT OF LIFE...**

**...AND IT *ALWAYS*  
WILL BE.**



LITTLE GIRL:

**BUT IF THE CLIMATE IS  
ALWAYS CHANGING THEN  
WHAT'S DIFFERENT  
THIS TIME?**

LITTLE BOY:

**WHAT DO  
PEOPLE HAVE  
TO DO WITH IT?**

**THAT'S A GOOD  
QUESTION!**

**LET'S START TO ANSWER  
IT BY TAKING A BRIEF LOOK  
AT THE HISTORY OF  
PLANET EARTH.**



*I THOUGHT IT'D BE FUN TO HAVE  
WARM CLOTHES AND WINTRY  
CONDITIONS IN THIS PANEL...  
NOT SURE IT WORKS YET, BUT  
PERHAPS THERE'S SOMETHING  
TO THE BRAINSTORM.*

*ONE SCIENTIST HOLDS A GLOBE,  
THE OTHER A FLASHLIGHT...  
NOT SURE IT MAKES SENSE, BUT  
I THOUGHT THERE WAS SOME  
CHANCE IT COULD FORSHADOW  
THE ENERGY IN AND OUT EARTH  
SUN RELATIONSHIP.*

# **CHAPTER 2**

## **A BRIEF HISTORY OF PLANET EARTH**

**TELL ME  
EVERYTHING  
THAT'S HAPPENED  
SO FAR.**

**WELL, FIRST  
THE EARTH  
COOLED...**

**...AND  
THEN THE  
DINOSAURS  
CAME...**



THE EARTH FORMED ABOUT  
**4.6 BILLION YEARS AGO.**

4.6 bya 4 bya 3 bya 2 bya 1 bya Now

THAT'S 50 MILLION  
TIMES OLDER THAN  
GRANDPA.



SCIENTIST OR  
DAD TO YOUNG  
CHILD, OF AFRICAN  
DESCENT



IN THE EARLY DAYS IT WAS A GREAT  
**MOLTEN BALL OF LIQUID ROCK...**

... WHICH BELCHED OUT **HOT GASES** AND **WATER VAPOR**  
TO FORM THE EARLY **ATMOSPHERE** AND **OCEANS.**



**PRIMITIVE LIFE FORMS** FIRST APPEARED IN  
THE OCEANS ABOUT A **BILLION YEARS LATER.**

4.6 bya Now

WHAT DO YOU  
CALL A SINGLE-CELLED  
ORGANISM FLOATING IN  
A PRIMORIDAL SEA?

**BOB.**



WHAT DO YOU  
CALL A SINGLE-CELLED  
ORGANISM SHAPED  
LIKE A TUBE?

**ROD.**



YOU AND YOUR  
JOKES ARE SO  
**PRIMITIVE!**



**THEN, AFTER HUNDREDS OF MILLIONS OF YEARS OF EVOLUTION...**

4,6 bya

Now

WHAT DO YOU CALL A SINGLE-CELLED ORGANISM THAT LIVES IN YOUR MAILBOX?

**BILL.**



WHAT DO YOU CALL A SINGLE-CELLED ORGANISM SMEARED ON THE WALL?

**ART.**



WILL YOU TWO SHUT UP!

I'M TRYING TO CONCENTRATE!



... SOME OF THESE ORGANISMS FIGURED OUT PHOTOSYNTHESIS...

**EUREKA!**



EEEK! HARRIET, COME BACK HERE!



... WHICH IS THE **CHEMICAL REACTION** THAT ALLOWS **GREEN THINGS** LIKE PLANTS AND ALGAE TO GROW.

PHOTOSYNTHESIS TURNS **SUNLIGHT, WATER AND CARBON DIOXIDE...**

... INTO THINGS LIKE **BROCCOLI AND BEAN SPROUTS.**

GREEN THINGS ARE THE **BASE OF THE FOOD CHAIN.**

WITHOUT **THEM** THERE COULD BE **NO US.**

OH **GREAT.**



**NOWADAYS, GREEN THINGS PLAY A KEY ROLE IN THE CARBON CYCLE...**

IN CHAPTER 4 WE'LL SEE THE INFLUENCE OF HUMAN ACTIVITY.

EVERY YEAR ABOUT **90 BILLION TONS** OF CARBON **DISSOLVES IN SEAWATER...**

...AND ABOUT THAT MUCH RETURNS TO THE ATMOSPHERE.

BECAUSE THE OTHERS HAVE IT, THIS FEELS LIKE IT NEEDS A VIA OR A THROUGH TO EXPLAIN HOW, EG. EVAPORATION.  
MAYBE "EVAPORATES INTO THE ATMOSPHERE?" OR???

MEANWHILE, ABOUT **120 BILLION TONS** GETS SUCKED IN BY **PLANTS** THROUGH **PHOTOSYNTHESIS...**

...AND ABOUT THAT MUCH RETURNS TO THE ATMOSPHERE THROUGH **FIRE, DECOMPOSITION, AND RESPIRATION** BY PLANTS AND ANIMALS.

PEEYEW!  
HOLDING NOSE.

SEE THE GLOSSARY FOR MORE DETAILS, LIKE **OCEANIC PHOTOSYNTHESIS**.

... WHICH IS CRUCIAL TO **ALL LIFE ON EARTH.**

YOU **ARE** WHAT YOU **EAT!**

MOSTLY WATER AND CARBON.

MOSTLY WATER AND CARBON.

MOSTLY WATER AND CARBON.

**BETWEEN ABOUT 2.5 AND 1.5 BILLION YEARS AGO, HOWEVER, GREEN THINGS DID SOMETHING PERHAPS EVEN MORE IMPORTANT.**

4.6 bya

Now

THEY PUMPED LOTS AND LOTS OF **OXYGEN** INTO THE ATMOSPHERE.

**ALL OF THE OXYGEN IN THE AIR GOT THERE THROUGH PHOTOSYNTHESIS!**

**GETTING OXYGEN ( $O_2$ ) INTO THE ATMOSPHERE WAS REALLY IMPORTANT BECAUSE...**

**DUH! BECAUSE ANIMALS NEED OXYGEN TO BREATHE.**

WELL, THAT'S TRUE...

... BUT THIS WAS A BILLION YEARS BEFORE **ANIMALS.**

**... BECAUSE IT LED TO THE CREATION OF A LAYER OF OZONE ( $O_3$ ) IN THE UPPER ATMOSPHERE.**

WHAT'S SO IMPORTANT ABOUT **THAT?**

WELL, **DUH.**

TURN THE PAGE TO FIND OUT.

OZONE LAYER

**BEFORE THE OZONE LAYER, THE ONLY PLACE LIFE  
COULD SURVIVE WAS IN THE OCEAN.**

4.6 bya

now

THE SUN GENERATES  
VISIBLE LIGHT...

... BUT IT ALSO GENERATES  
DEADLY ULTRAVIOLET  
RADIATION.

**AFTER THE OZONE LAYER, THE  
SUN'S DEADLIEST UV RAYS GOT BLOCKED...**

4.6 bya

now

**OZONE IS LIKE  
SUNSCREEN  
FOR THE ENTIRE  
PLANET.**

**SUNSCREEN**  
Protects against UVA and UVB for up to 2  
HOURS.

**OZONE**  
Protects against DEADLY UVC For BILLIONS OF  
YEARS and counting.

Now with CATALYTIC ACTION!

**... AND, ABOUT ABOUT A BILLION YEARS AGO,  
LIFE STARTED MOVING ONTO THE LAND.**

4.6 bya

Now

OH NO, HARRIET,  
NOT AGAIN!

**NO WONDER EVERYBODY GOT WORRIED WHEN SCIENTISTS DISCOVERED  
A HOLE IN THE OZONE LAYER IN THE 1980s.**

DESPITE WHAT MANY PEOPLE THINK,  
THE OZONE HOLE IS **NOT** CLOSELY  
RELATED TO GLOBAL WARMING...

ENVIRONMENTAL  
PROBLEMS ARE **NOT**  
ALL THE SAME...

... AND YOU CAN'T  
SOLVE THEM ALL BY  
**RECYCLING.**

... BUT IT IS VALUABLE TO **COMPARE** AND **CONTRAST** THE TWO ISSUES...

THE OZONE HOLE IS  
RELATED TO HUMAN EMISSIONS OF  
**OZONE-DESTROYING** GASES SUCH  
AS **CHLOROFLUOROCARBONS**  
(CFC's)...

... WHICH WE USED TO PUT  
IN **AEROSOL CANS** AND  
**REFRIGERATORS.**

GLOBAL WARMING IS RELATED  
TO HUMAN EMISSIONS OF  
**GREENHOUSE** GASES SUCH AS  
**CARBON DIOXIDE (CO<sub>2</sub>)...**

... WHICH GETS  
EMITTED WHENEVER  
YOU BURN STUFF.

... AND WE CAN TAKE HEART FROM THE **PROGRESS**  
WE'VE MADE IN REPAIRING THE OZONE HOLE.

PRESIDENT REAGAN  
HELPED PHASE OUT CFCs  
AND THE OZONE LAYER IS  
**RECOVERING.**

IF ONLY GLOBAL  
WARMING WERE  
SO **EASY!**

SHOULDN'T WE MENTION THE  
MONTREAL PROTOCOL HERER?

ISN'T IT MORE IMPORTANT THAT THE  
PRESIDENT WHO HAPPENED TO SIGN  
IT? OR IS HE IN HERE FOR REASONS OF  
ENDORISING COLLABORATION?

**BUT LET'S GET BACK TO THE  
HISTORY OF PLANET EARTH...**

**THE PAST BILLION YEARS HAVE SEEN  
WILD CHANGES IN THE CLIMATE.**

4.6 bya

Now

**THE ONLY THING  
PERMANENT IS  
CHANGE.**

**THERE WERE TIMES WHEN  
ICE COVERED ALMOST EVERYTHING...**

4.6 bya

Now

**YORAM NEEDS TO WORK ON THIS TIMELINE.**

**THIS SNOWBALL  
EARTH IS FREEZING!**

**GOOD THING THERE  
WEREN'T ACTUALLY  
PEOPLE BACK THEN.**

**THIS IS THE DENIER KID, WHO LIKES  
SUMMER.**

**THIS IS THE ALARMIST KID, WHO LIKES  
WINTER.**

**... AND AT LEAST ONE TIME WHEN  
THE NORTH POLE WAS TROPICAL.**

4.6 bya

Now

**YORAM NEEDS TO WORK ON THIS TIMELINE.**

**BOY, I COULD REALLY  
USE SOME ICED TEA!**

**GOOD THING THERE  
WEREN'T ACTUALLY  
PEOPLE BACK THEN.**

**SORRY, THERE'S  
NO ICE.**

OF CENTRAL IMPORTANCE TO OUR STORY IS THE **CARBONIFEROUS PERIOD**, SOME **300–350 MILLION YEARS AGO...**

4,6 bya

Now

**GIANT SCORPIONS!**

**GIANT COCKROACHES!**

**GIANT CROCODILES!**

... BECAUSE SOME OF THE ORGANISMS THAT **DIED** THEN GOT BURIED...

WHAT DO YOU CALL A SINGLE-CELLED ORGANISM LYING IN A HOLE?

**DOUG.**

... AND COOKED UNDERGROUND FOR **HUNDREDS OF MILLIONS OF YEARS...**

KNOCK KNOCK

WHO'S THERE?

OIL,

OIL WHO?

OIL BE BACK.

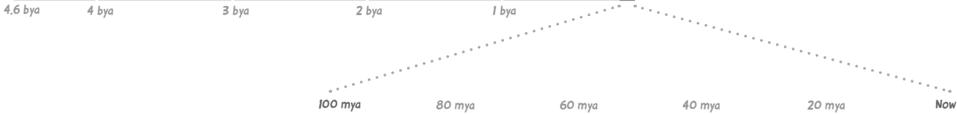
... AND EVENTUALLY TURNED INTO **CARBON-BASED FOSSIL FUELS.**

THAT'S WHERE A LOT OF OUR **COAL** COMES FROM...

... AND PLENTY OF **OIL AND NATURAL GAS** TOO.

SCORPION LOGO LIKE SIGNATURE

**DURING THE LAST 100 MILLION YEARS...**



**... THE CONTINENTS SLOWLY DRIFTED INTO THE POSITIONS THEY HAVE TODAY...**

CONTINENTS MOVE AT ABOUT THE SPEED THAT YOUR FINGERNAILS GROW...

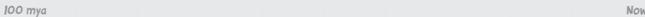
... ABOUT 100 MILES EVERY MILLION YEARS.

**... AND SPECIES EITHER DIED OFF OR SLOWLY EVOLVED INTO THE FORMS THEY HAVE TODAY.**

THANKS TO AN ASTEROID 65 MILLION YEARS AGO...

... WE SAID GOODBYE TO THE VELOCIRAPTOR...

... AND HELLO TO THE CHICKEN.



**EVEN MORE RECENTLY, THE EARTH'S CLIMATE HAS CALMED DOWN A BIT...**

**... BUT CALM IS A RELATIVE TERM.**

*YORAM NEEDS TO DOUBLE-CHECK THIS FRAME.*

NO SNOWBALL EARTHS...

... AND NO TROPICAL NORTH POLES!

LOOK, WE'VE CALMED DOWN!

WOW, WHAT WERE YOU LIKE BEFORE?



**IN PARTICULAR, OVER THE PAST  
2.5 MILLION YEARS THE PLANET HAS GONE  
THROUGH PERIODIC CYCLES...**

HOW ABOUT A ROLLER COASTER HERE? WE COULD HAVE IT  
ROUGHLY FOLLOW THE TEMPERATURE PROFILE OVER THE LAST  
2.5 MILLION YEARS, AND IN DOING SO IT WOULD FORESHADOW  
THE STUFF IN THE NEXT CHAPTER.

WE ONLY HAVE THE LAST 300,000 DEPICTED IN THE NEXT  
CHAPTER, BUT I SUSPECT THE ROLLER COASTER WILL GET IT  
ACROSS JUST FINE.

**... OF WARM PERIODS...**



**... AND COOL PERIODS.**

SCIENTISTS CALL THESE  
COOL PARTS **GLACIAL  
PERIODS.**

EVERYONE  
ELSE CALLS THEM  
**ICE AGES.**



100 mya

Now

**MODERN HUMAN BEINGS APPEARED IN AFRICA ONLY ABOUT 200,000 YEARS AGO...**

THAT'S ONLY 2,000 TIMES OLDER THAN GRANDPA.

HUMAN TIME SCALES ARE WAY DIFFERENT THAN GEOLOGIC TIME SCALES.

# TA DA!

DON'T FORGET THIS CHARACTER NEEDS RELATIVELY DARK SKIN.

**... AND IT WASN'T LONG BEFORE THEY STARTED ASKING TOUGH QUESTIONS.**

I WONDER HOW I CAN **AVOID BEING EATEN?**

I WONDER WHAT **CAUSED THE ICE AGES?**

I WONDER WHERE I **FIND SOME SALT?**

# CHAPTER 3

## THE ICE AGES

GO BACK 15,000 YEARS  
AND THIS WAS UNDER A  
**MILE OF ICE!**



ALT, SOME WAY TO EXPAND THIS GAG?:

GO BACK 15 MINUTES AND THIS WAS XYZ...

THEN:

GO BACK 15,000 YEARS AND THIS WAS UNDER A **MILE OF ICE!**

EARLY GEOLOGISTS HYPOTHESIZED THAT THERE **MUST** HAVE BEEN **ICE AGES**.

WHAT COULD HAVE CARRIED THESE GIANT ROCKS HERE FROM THOSE DISTANT MOUNTAINS?

THERE MUST HAVE BEEN **MASSIVE GLACIERS!**

OR **PREHISTORIC GIANTS!**

20TH CENTURY SCIENTISTS **CONFIRMED** THIS BY STUDYING EARTH'S TWO REMAINING **GIANT ICE SHEETS**,

ONE'S OVER **GREENLAND...**

... THE OTHER'S OVER **ANTARCTICA**

THESE ICE SHEETS WERE BUILT UP OVER **HUNDREDS OF THOUSANDS OF YEARS.**

**Glaciers  
Snow  
Got  
Compressed,  
Trapping Ancient Air  
in Ancient Ice.**

**BY DRILLING DOWN THROUGH THAT ICE...**

I'VE GOT A 6-FOOT COD!



**... AND ANALYZING THE VARIOUS LAYERS...**

I'VE GOT A MILE-LONG ICE CORE!



IT'S LIKE COUNTING TREE RINGS.



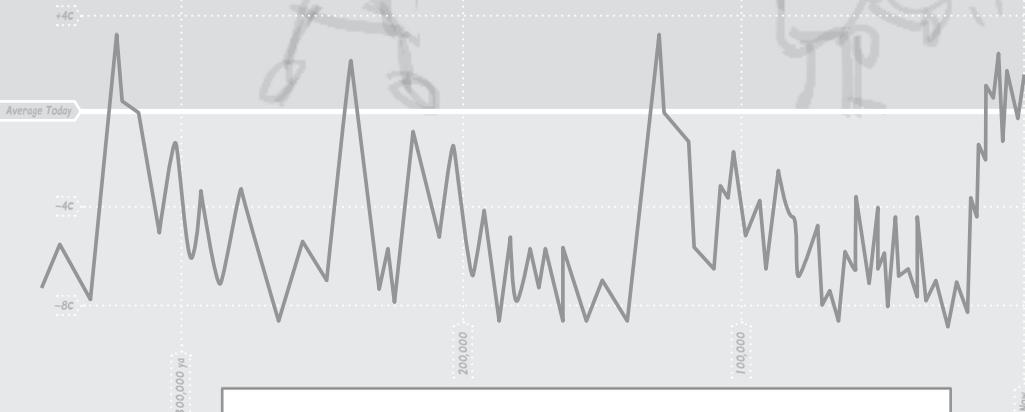
**... SCIENTISTS CAN ESTIMATE THE AVERAGE SURFACE TEMPERATURE OF PLANET EARTH FAR INTO THE DISTANT PAST.**

OVER THE PAST 400,000 YEARS THERE HAVE BEEN WARM PERIODS...

TWEAK TO 350,000 WHICH IS CLOSER TO WHAT THE GRAPH SHOWS?

... INCLUDING THE PAST 10,000 YEARS.

BUT THOSE WARM PERIODS HAVE BEEN THE EXCEPTIONS.



**THESE ICE CORES SHOW THAT EARTH HAS USUALLY BEEN 4-8°C (7-14°F) COLDER THAN IT IS NOW.**

THOSE SMALL TEMPERATURE CHANGES...

... WERE ENOUGH TO BURY CHICAGO WITH ICE.

MIND IF WE SAY THIS INSTEAD? EASIER TO DRAW AND KEEPS US FROM NEEDLESSLY REPEATING MILE OF ICE.

OLD:

... WERE ENOUGH TO PLIT CHICAGO UNDER A MILE OF ICE.



**THE MYSTERY OF THE ICE AGES...**

I WONDER WHY THERE AREN'T **GLACIERS** HERE ANYMORE?

AND DON'T SAY **PREHISTORIC GIANTS!**

... WAS MOSTLY SOLVED BY THE SERBIAN MATHEMATICIAN **MILUTIN MILANKOVITCH** DURING THE FIRST WORLD WAR.

THE **REAL MYSTERY** IS WHY WE'RE FIGHTING THIS **DUMB WAR!**

HE STUDIED THE **DETAILS** OF THE EARTH'S **ORBIT AROUND THE SUN...**

IT ORBITS ONCE A YEAR...

... BUT AS IT DOES IT **MEANDERS** AND **WOBBLES** A BIT.

... INCLUDING THE **TILT** OF THE EARTH, WHICH CAUSES **WINTERS** AND **SUMMERS**.

IN **JULY** THE NORTHERN HEMISPHERE GETS **MORE SUN...**



IN **JANUARY** THE NORTHERN HEMISPHERE IS DARK AND COLD...



... AND THE SOUTHERN HEMISPHERE IS **DARK** AND **COLD**.

... AND THE SOUTHERN HEMISPHERE GETS **MORE SUN**.

OCTOBER

APRIL

NOT TO SCALE.

**IT TURNS OUT THAT THE TILT *VARIABLES* OVER TENS OF THOUSANDS OF YEARS.**



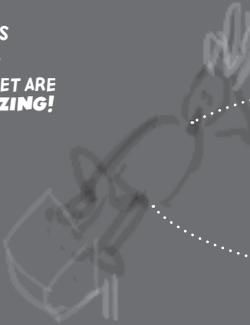
WE'LL HAVE AN UPDATE IN **9,000 YEARS.**



**WHEN THE TILT IS STRONGER, SEASONS ARE STRONGER...**

MY HEAD IS **ON FIRE,**

MY FEET ARE **FREEZING!**



MY FEET ARE **ON FIRE,**

MY HEAD IS **FREEZING!**



**...AND WHEN THE TILT IS WEAKER, SEASONS ARE WEAKER.**

I'M GETTING **COOKED** A MORE **EVEN** AMOUNT **ALL AROUND...**



... **NO MATTER WHAT** TIME OF YEAR IT IS,

**TWO OTHER ORBITAL VARIATIONS ALSO AFFECT THE STRENGTH OF THE SEASONS.**

THEY'RE THE **MILANKOVITCH CYCLES.**



THE **MILANKOVITCH CYCLE** THEORY SAYS THAT THESE ORBITAL VARIATIONS...



... SET THE **RHYTHM** FOR THE ICE AGES...

START ROCK BAND/ MARCHING BAND ANALOGY HERE, MM IS THE DRUMMER FOR THE BAND



... BY TRIGGERING **POSITIVE FEEDBACK LOOPS.**



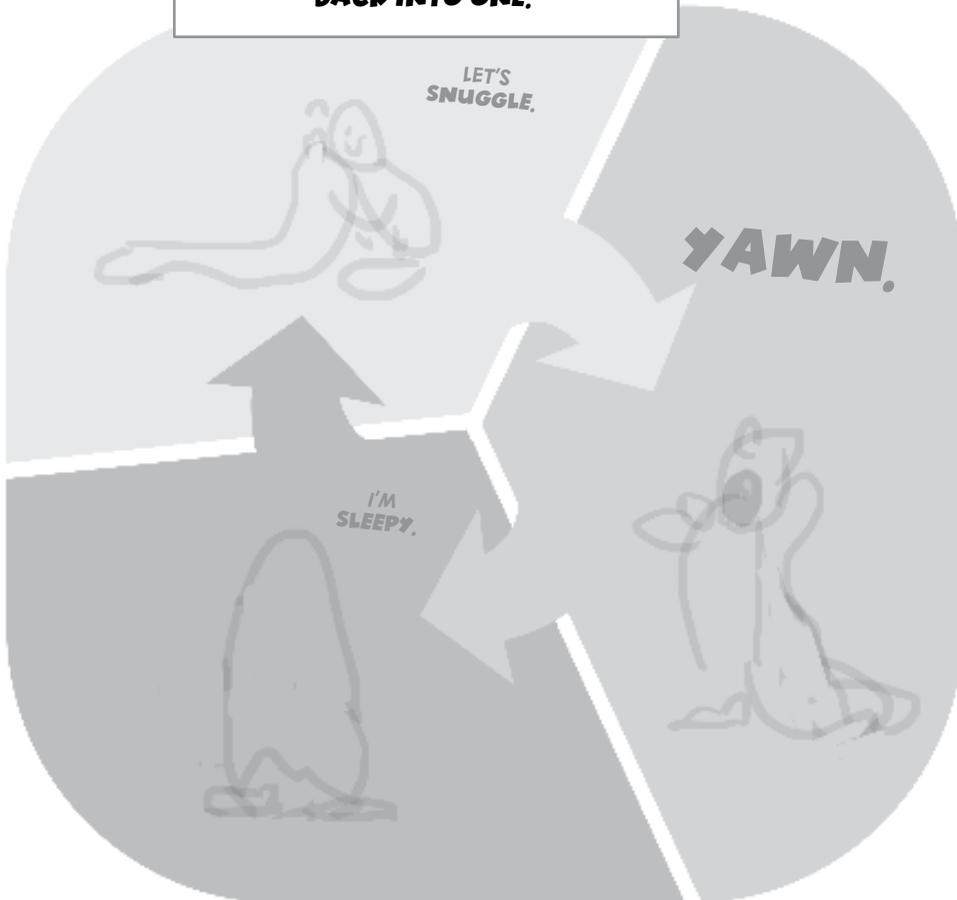
**SOMETIMES THOSE POSITIVE FEEDBACK LOOPS BRING THE EARTH  
OUT OF AN ICE AGE...**



*I'M GOING  
INTERGLACIAL!*



**...AND SOMETIMES THEY SEND US  
BACK INTO ONE.**



*ZZZZZZZ.*



**LET'S SEE HOW IT WORKS IN CLOSER DETAIL.**

FOR  
A **SIMPLIFIED**  
**VERSION** OF  
THE MILANKOVITCH  
STORY...

FOR MORE DETAILS,  
SEE **ICE AGES** IN THE  
GLOSSARY...



MILANKOVITCH:

... OR READ MY  
**626-PAGE BOOK!**

... IMAGINE WE'RE IN **CANADA** DURING A **GLACIAL PERIOD**.

LIKE THE ONE THAT  
PEAKED **20,000**  
**YEARS** AGO.

THE MILANKOVITCH CYCLES EVENTUALLY CREATE  
CONDITIONS WITH **STRONG SEASONS**.

**HOT HOT SUMMERS.**

LOTS OF MELTING  
ICE AND SNOW.



FEET STICKING OUT OF HOLE  
IN THE ICE.

**COLD COLD WINTERS.**

BUT THERE ISN'T ENOUGH  
NEW SNOW TO KEEP UP  
WITH THE SUMMER MELT.



SAME FEET STICK OUT OF THE ICE, BUT NOW THE HOLE IS FROZEN OVER  
AND THERE'S A BIG ICE CUBE AROUND THE FEET.

THAT CAUSES **ICE AND SNOW** TO GIVE WAY TO **LAND AND WATER**.

BACKGROUND HERE IS LAND... IT'S THE SAME BACKGROUND AS  
THE ABOVE SHOT, BUT MOST OF THE ABOVE IS OBSCURED BY  
GLACIAL ICE...

IN THIS ONE, THERE'S ONLY ICE UNDERNEATH THEM

NOW WE CAN  
PLANT **MAPLE**  
**SYRUP TREES!**



**AMPLIFYING THE MILANKOVITCH CYCLES ARE THINGS LIKE THE ALBEDO EFFECT...**

ICE AND SNOW  
**REFLECT** LOTS OF  
SUNLIGHT BACK INTO  
SPACE.

LAND AND WATER  
**ABSORB** MORE  
SUNLIGHT, WARMING  
THE PLANET.

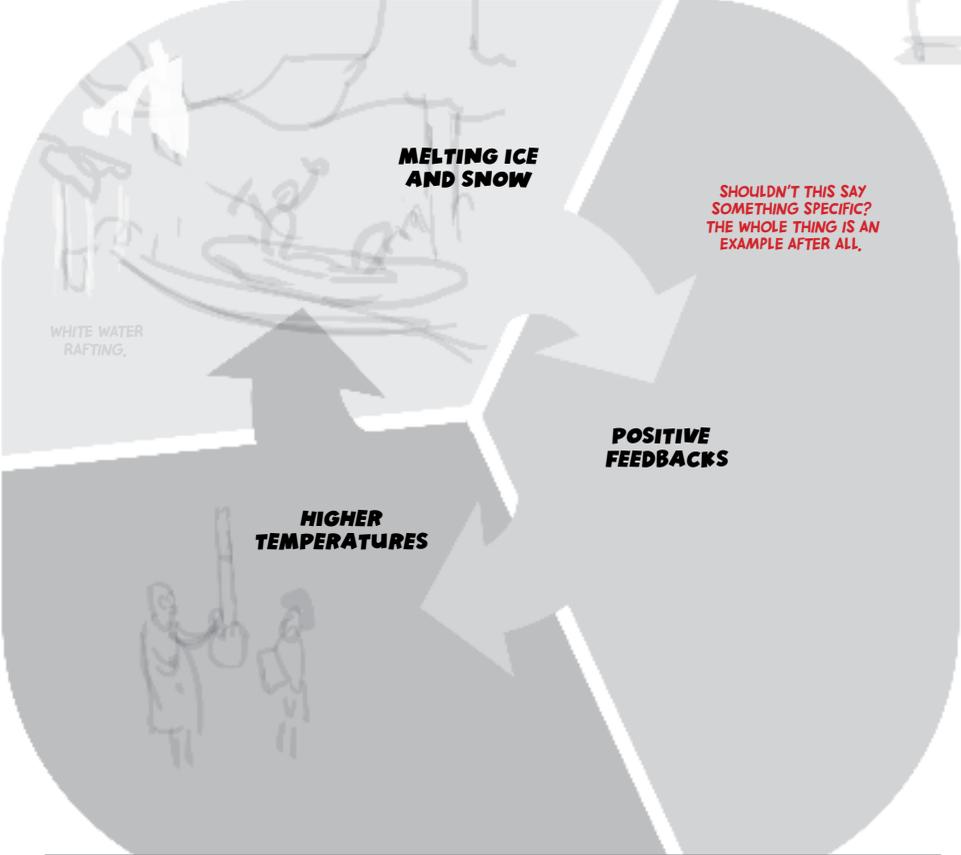
THEY ARE MEMBERS  
OF MM'S BAND!

THIS IS THE BALD BASSIST

THIS IS THE LEAD SINGER/GUITARIST  
WITH ROCK STAR HAIR!!!!

HOW ABOUT HERE ... "WHICH WORK TO FEED POSITIVE FEEDBACK LOOPS,"  
SO THEN WE CAN PUT "THE ALBEDO" WHERE THE RED COMMENT IS,

**... AND OTHER POSITIVE FEEDBACK LOOPS.**



**IN THIS WAY THE MILANKOVITCH CYCLES, COMBINED WITH POSITIVE FEEDBACK LOOPS, CREATE AN INTERGLACIAL PERIOD.**



IT SURE IS **HOT**  
AND **LOUD** IN  
HERE,

**WHAT??**

TO SEE HOW IT WORKS IN THE OTHER DIRECTION,  
IMAGINE WE'RE IN THE MIDDLE OF AN **INTERGLACIAL PERIOD**.

LIKE THE ONE  
WE'RE IN **NOW**.



Tonight at the **Mammoth Room**:  
Milankovitch and the Feedbacks  
7 pm no cover



THE MILANKOVITCH CYCLES EVENTUALLY CREATE CONDITIONS WITH **MILD SEASONS**,

**MILD SUMMERS.**

DRIP OF  
WATER.



NOT MUCH  
MELTING ICE  
AND SNOW.

**MILD WINTERS.**

TURNS  
INTO AN  
ICYCLE.



BUT STILL COLD  
ENOUGH FOR SNOW  
IN PLACES LIKE  
**CANADA**.



THAT CAUSES **ICE AND SNOW** TO SLOWLY REPLACE **LAND AND WATER**.

WHAT'S MORE CANADIAN  
THAN **MAPLE SYRUP**?

**ICE  
HOCKEY!**



HOCKEY... THEY WEAR SOME KIND OF SKINS AND THE GOAL IS MADE OF SOME  
MEGAFALUNA RIBCAGE AND THE GOALIE HAS A SKULL OVER HIS FACE AS A FACEMASK...

NOW THE **ALBEDO EFFECT** WORKS IN THE **OTHER DIRECTION...**

LAND AND WATER THAT **ABSORB** LOTS OF SUNLIGHT...

...GET COVERED WITH ICE AND SNOW THAT **REFLECT** SUNLIGHT, COOLING THE PLANET.

BALD GUY AGAIN.

...AS DO OTHER **POSITIVE FEEDBACK LOOPS.**

MAYBE "MORE" INSTEAD OF "EXPANDING"?

**EXPANDING ICE AND SNOW**

TRYING TO PADDLE INFLATABLE ROWBOAT IN SNOW... OR PERHAPS ENJOYING USING IT AS A SLED.

**LOWER TEMPERATURES**

**POSITIVE FEEDBACKS**

ALBEDO, WATER VAPOR, CO<sub>2</sub>, ALTITUDE?

SEE THE **GLOSSARY** FOR DETAILS.

ALL THIS BRINGS UP A **PRETTY OBVIOUS QUESTION.**

GIVEN THAT WE'RE **CURRENTLY** IN AN **INTERGLACIAL PERIOD...**

... SHOULD I WORRY ABOUT THE **NEXT ICE AGE?**

THE **ANSWER** IS THAT MOTHER NATURE **IS**  
GEARING UP FOR **ANOTHER ICE AGE...**

OH NO, I BETTER  
STOCK UP ON  
HEATING OIL!

... BUT NOT FOR AT LEAST **30,000 YEARS.**

AH, **NEVER**  
**MIND!**

A MORE IMMEDIATE CONCERN IS THE **HUMAN INFLUENCE**  
ON THE ATMOSPHERE AND THE CLIMATE.

UM, ABOUT THAT  
**HEATING OIL...**



# CHAPTER 4

## CARBON DIOXIDE

MIGHT BE FUN TO PULL APART THIS TEXT  
SO THAT THE ZEROS LOOK A BIT LIKE GAS  
MOLECULES. COULD BE A SIMPLE SIGHT GAG,  
I'D MAKE SURE TO USE THE RIGHT NUMBER OF  
ZEROS, BUT THERE'S TOO MANY ZEROS HERE  
TO COUNT ANYWAY.

WITH EVERY BREATH OF  
AIR YOU INHALE ABOUT  
**10,000,000,000,000,000,000,000**  
GAS MOLECULES...

... INCLUDING ABOUT  
**2,100,000,000,000,000,000,000**  
MOLECULES OF O<sub>2</sub>...

... AND ABOUT  
**4,000,000,000,000,000,000**  
MOLECULES OF CO<sub>2</sub>.



ALT.

PERHAPS ZEROS ENTER A  
CHARACTER'S OPEN MOUTH.

WHAT WE CALL **AIR** IS ACTUALLY A MIXTURE THAT'S ABOUT **21% OXYGEN...**

CREATED OVER THE EONS BY ALL THAT PHOTOSYNTHESIZING **GREEN STUFF.**

REMEMBER TO DEPICT IN PICTURE, IN OCEANS AND ON LAND.

... AND ABOUT **78% NITROGEN.**

A NITROGEN DAY RALLY HERE WITH LOTS OF PUNS ABOUT ATMOSPHERIC NITROGEN, N<sub>2</sub>:

I'M INTO N<sub>2</sub>

N<sub>2</sub> DEEP

N<sub>2</sub> THE DRAGON

N<sub>2</sub> THE NTH POWER

THE **REMAINING 1% INCLUDES WATER VAPOR...**

[MAYBE HAVE A KID AT A BLACKBOARD SHOWING  $21+78=99$ , AND IT'S RAINING OUTSIDE?] OR MAYBE SOMETHING ABOUT EVAPORATION AND THE WATER CYCLE?]

... AND **TINY AMOUNTS, MEASURED IN PARTS PER MILLION (PPM), OF OTHER GASES SUCH AS CARBON DIOXIDE (CO<sub>2</sub>).**

IT'S **ODORLESS, COLORLESS, AND INVISIBLE...**

... AND IT'S THE FOCUS OF THIS CHAPTER!

**IN THE EARLY 1950S A CHEMIST NAMED  
CHARLES DAVID KEELING...**

CALL ME DAVE,

**... FIGURED OUT A WAY TO ACCURATELY MEASURE  
THE CONCENTRATION OF CARBON DIOXIDE IN AIR.**

HOW ABOUT SOMETHING LIKE HE'S  
GOT TWO BALLOONS ON A SCALE OR IS  
COMPARING TWO BALLOONS OR TWO  
BAGS OR TWO SAMPLES AND HE SAYS:

WHAT'S THE  
CO2 DIFFERENCE  
BETWEEN THESE  
TWO SAMPLES?

ONE IN A  
MILLION!

**STARTING IN 1958, KEELING AND HIS COLLEAGUES MADE DAILY MEASUREMENTS  
OF CO2 AT THE MAUNA LOA OBSERVATORY IN HAWAII...**

Y BRAINSTORM:

**C'MON DAD, LET'S  
GO TO THE BEACH!**

**SORRY, KID,  
NOT NOW.**

MIGHT BE USEFUL FOR A  
CALLBACK WHEN WE DO  
OCEAN ACIDIFICATION,  
PERHAPS A LINE LIKE  
"SORRY, KID, NOT EVER."

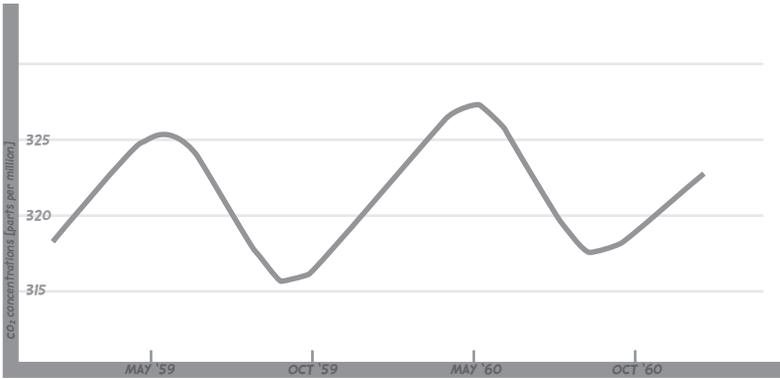
WEARING SNORKELING GEAR

**... AND THE RESULTS MADE HIM FAMOUS.**

WELL, NOT **ROCK STAR**  
FAMOUS...

... MORE LIKE  
**NICHE FAMOUS.**

**KEELING MADE TWO BIG DISCOVERIES. FIRST, HE DISCOVERED AN ANNUAL CYCLE IN CO2 CONCENTRATIONS.**



DJ  
(RASTAFARIAN):  
**DUDE, IT'S LIKE THE PLANET IS BREATHING!**

D2 (SCIENTIST OR BUSINESS TYPE):

OKAY, HIPPIE, TAKE IT EASY.

**THIS CYCLE IS RELATED TO THE SEASONS...**



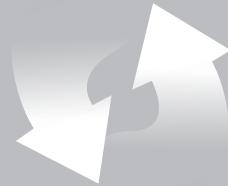
LOOK AT PAGE #!

HOLDING TILT GRAPHIC FROM PREVIOUS CHAPTER, BUT THE PICTURE WILL HAVE THE SUN SHINING ON IT.

**...AND TO THE CARBON CYCLE...**

LOOK AT PAGE 7!

HOLDING CARBON ARROW FROM PREVIOUS CHAPTER,



**...AND TO THE FACT THAT MOST OF THE LAND ON EARTH IS IN THE NORTHERN HEMISPHERE.**

LOOK AT A MAP!



**MORE LAND MEANS MORE GREEN STUFF.**

THIS WILL BE HAND DRAWN, WITH STRONGER CONTRAST BETWEEN LAND AND SEA

PLUS CLEAR EQUATOR AND HIGHLIGHT OF NORTH V SOUTH

**DURING THE NORTHERN HEMISPHERE WINTER, CO2 GETS "EXHALED" INTO THE ATMOSPHERE...**

**... THANKS TO PROCESSES LIKE THE DECOMPOSITION OF FALLING LEAVES,**



OF COURSE, WINTER IN THE NORTH IS **SUMMER IN THE SOUTH...**

... BUT THE SOUTH IS LESS IMPORTANT BECAUSE THERE'S **NOT MUCH LAND.**

**THEN DURING THE NORTHERN HEMISPHERE SUMMER, CO2 GETS "INHALED" OUT OF THE ATMOSPHERE...**

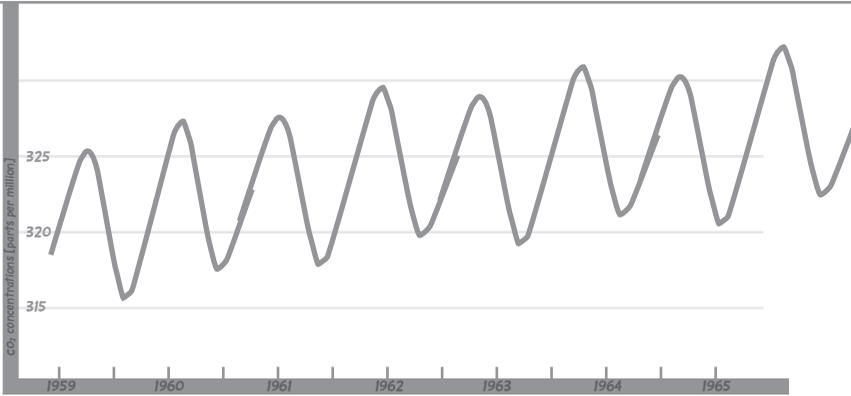
**... BY INCREASED PHOTOSYNTHESIS.**



ALL THE **GREEN STUFF** GROWING IN THE **NORTH...**

... SWAMPS THE IMPACT OF THE SOUTHERN HEMISPHERE WINTER,

**KEELING'S SECOND BIG DISCOVERY WAS THAT CO2 CONCENTRATIONS IN THE ATMOSPHERE WERE INCREASING OVER TIME.**



SOME GAG HERE ABOUT IT GOING UP.

**WHEN KEELING STARTED IN 1958, THE INCREASE WAS ABOUT 1 PART PER MILLION (PPM) PER YEAR.**

EVERY INCREASE OF 1 PPM  
EQUALS 7.8 BILLION TONS  
OF CO2...

...OR 2.1 BILLION  
TONS OF CARBON...

...BECAUSE THERE'S  
1 TON OF CARBON  
ATOMS...

...IN EVERY 3.67  
TONS OF CO2  
MOLECULES.

HOLDING THIS UP,

HOLDING THESE UP,



**KEELING'S MEASUREMENTS CONTINUED FOR YEARS AND THEN DECADES,  
AND AFTER HIS RETIREMENT HIS SON STEPPED INTO HIS SHOES.**

THIS TIME IT'S THE DAD IS GRANDPA AGE,  
THE SON IS DAD AGE, AND THE LINES ARE  
VIRTUALLY THE SAME:

C'MON SON, LET'S  
GO TO THE **BEACH!**

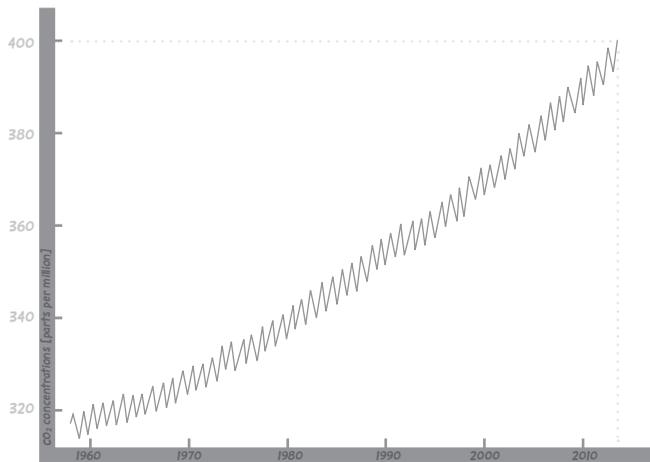
SORRY, DAD,  
NOT NOW.

THIS TIME IT'S THE DAD IS GRANDPA AGE,  
THE SON IS DAD AGE, AND THE LINES ARE  
VIRTUALLY THE SAME:

WITH SNORKLE AND FINS,

[MAYBE THE BLACKBOARD CONTINUES DOWN THE PAGE,  
AND RALPH IS SAYING "2000 / 370PPM, 2010 / 390  
PPM"]

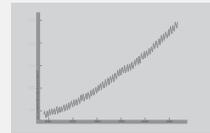
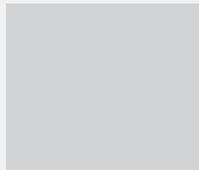
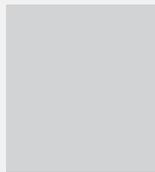
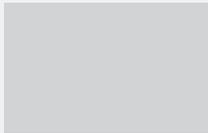
THE GRAPH OF THE DAILY MEASUREMENTS THAT THEY AND THEIR COLLEAGUES HAVE MADE SINCE 1958 IS CALLED THE **KEELING CURVE**.



IN 2013, WE'RE AT **400 PPM** AND INCREASING BY ABOUT **2 PPM PER YEAR**.

I'D MUCH PREFER HAVING A CHARACTER SAY THIS AND POINT WITH A STICK THAN PUT THIS TEXT IN AN ARROW.

IT IS NOW ONE OF THE **MOST FAMOUS IMAGES** IN THE WORLD...



MUSEUM WITH THE MONA LISA  
AND MONDRIAN  
AND THE SCREAM  
AND THE KEELING CURVE

... AND ONE OF THE CENTRAL PIECES OF **EVIDENCE** IN THIS BOOK.

PERHAPS ENDING WITH A FAVORITE ART CRITICISM QUERY:

WHAT DOES IT **MEAN?**

IT MEANS THAT **HUMAN ACTIVITY IS CHANGING THE PLANET!**

IN THE 19TH CENTURY THE MAJOR SOURCE OF HUMAN CO2 EMISSIONS WAS **DEFORESTATION...**

CLEARING TREES TO MAKE ROOM FOR FARMS AND CITIES...

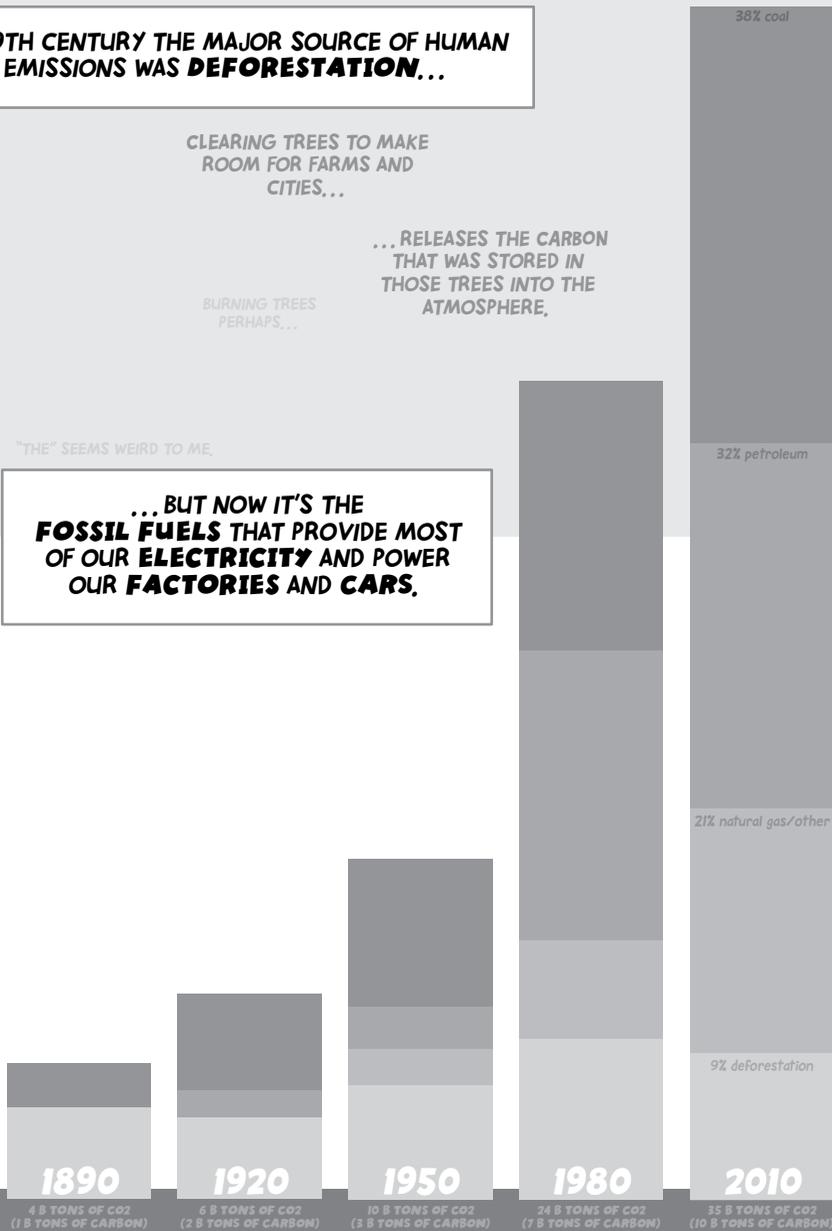
BURNING TREES PERHAPS...

... RELEASES THE CARBON THAT WAS STORED IN THOSE TREES INTO THE ATMOSPHERE,

SMOKE CONTINUES OVER HERE,

"THE" SEEMS WEIRD TO ME,

... BUT NOW IT'S THE **FOSSIL FUELS** THAT PROVIDE MOST OF OUR **ELECTRICITY** AND POWER OUR **FACTORIES** AND **CARS**.



BY 2010 WE WERE BURNING THROUGH 44,000 GALLONS OF PETROLEUM **EVERY SECOND**.

ABOUT **HALF** OF THAT EXTRA CO2 GETS ABSORBED BY **PLANTS...**

FORESTS STILL COVER ABOUT 1/3 OF THE EARTH'S LAND,

WE'LL COME BACK TO THIS IN **CH 15**.

... AND BY OTHER **CARBON SINKS** SUCH AS THE **OCEANS...**

WE'LL COME BACK TO THIS IN CHAPTER **\*\*\***, ON **OCEAN ACIDIFICATION**.

... BUT THE REST **STAYS IN THE ATMOSPHERE**, PUSHING UP THE KEELING CURVE,

NOTE THAT IN SEPTEMBER WE NEED TO REVISIT THESE NUMBERS.

HERE'S HOW THE **CARBON CYCLE** IS AFFECTED BY THE **10 BILLION TONS** OF CARBON EMITTED BY HUMAN ACTIVITY **EACH YEAR**:

PLANES

ABOUT **4 BILLION TONS** REMAIN IN THE **ATMOSPHERE...**

**119.6**  
BILLION  
TONS

**122.6**  
BILLION  
TONS

**90.6**  
BILLION  
TONS

**92.2**  
BILLION  
TONS

... ABOUT **3 BILLION TONS** ARE ADDED TO THE **OCEANS...**

A **FACTORY**

**SOME CARS**

**SHIPS**

... AND ABOUT **3 BILLION TONS** ARE ABSORBED BY **PLANTS AND SOILS.**

SCIENTIST IN CAR WITH TRAILER THAT HAS A PLANT ON IT PERHAPS.

**HUMAN EMISSIONS ARE A SMALL FRACTION OF THE NATURAL CYCLE, BUT OVER TIME IT ADDS UP.**

INHALE MORE THAN YOU EXHALE...

... AND PRETTY SOON YOUR LUNGS WILL **E#PLODE.**

HIPPIES FROM THE PREVIOUS SPREAD

SCIENTISTS HAVE ALSO PUT THE KEELING CURVE IN **HISTORICAL CONTEXT...**

WHAT DID CO<sub>2</sub> CONCENTRATIONS LOOK LIKE BEFORE 1958?

LOOKING LEFT,

...BY STUDYING THE AMOUNT OF CO<sub>2</sub> TRAPPED IN **ICE CORES.**

WE LEARNED ABOUT THESE IN CHAPTER 3,

HOLDING ICE CORE,

AS YOU CAN SEE, **TODAY'S LEVELS ARE OFF THE CHARTS** COMPARED TO THE LAST 350,000 YEARS.

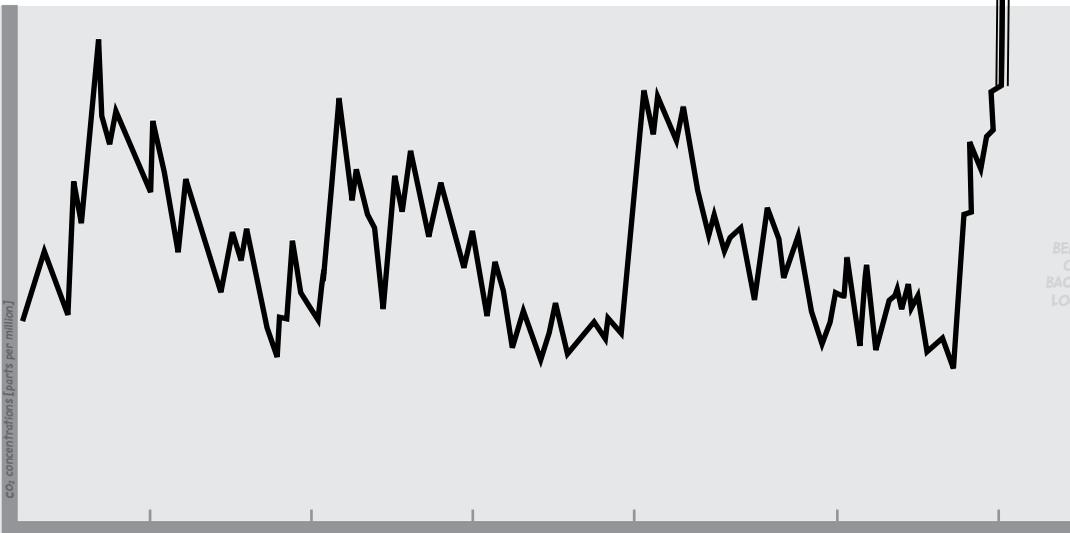
LITTLE CHARACTERS OR ARROWS CAN POINT THESE OUT:

≈1900: 300 PPM  
≈2013: 400 PPM

400

300

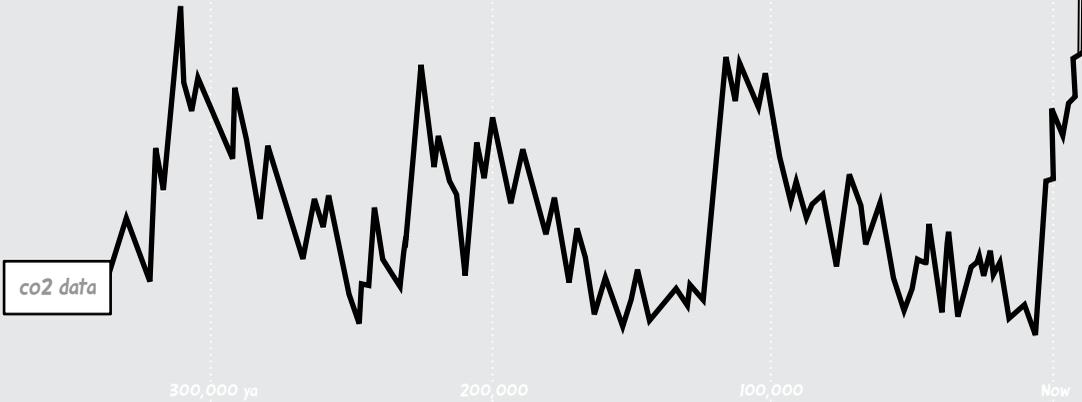
200



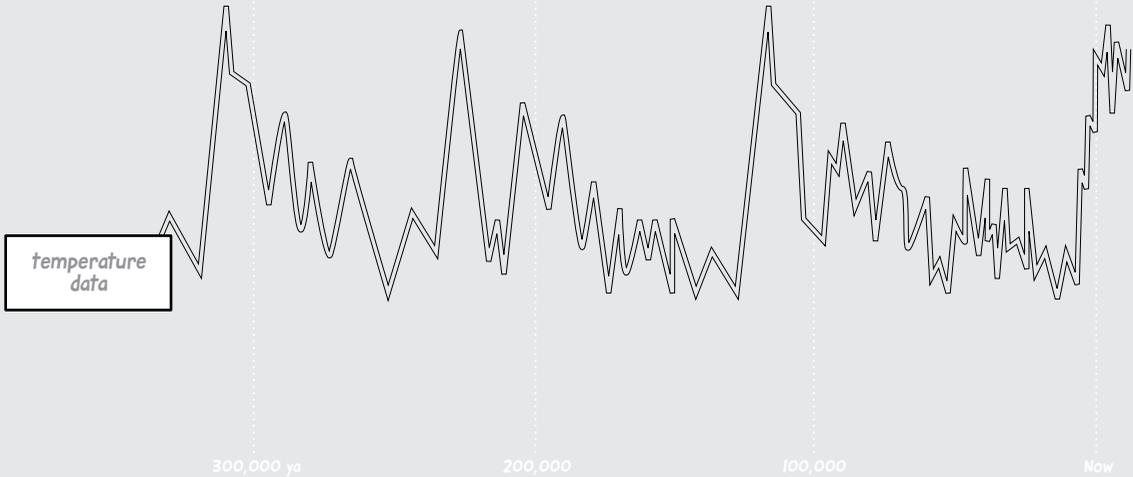
BENDING OVER BACKWARD LOOKING UP,

JUST A NOTE THAT THE AXES HERE NEED A BIT OF WORK WITH LABELS AND TICKMARKS.

**EVEN MORE AMAZING IS THE RELATIONSHIP BETWEEN THIS HISTORIC CO2 DATA...**



**... AND THE ICE CORE TEMPERATURE DATA FROM PAGE X.**

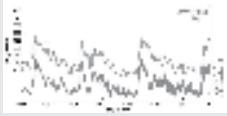


**IT'S OBVIOUS THAT CO2 AND TEMPERATURE HAVE BEEN CLOSELY RELATED FOR THE PAST 350,000 YEARS.**

**WHAT ARE THE ODDS  
OF THAT HAPPENING  
BY CHANCE?**

**LESS THAN ONE  
IN A MILLION!**

**THE CONNECTION BETWEEN CO2 AND TEMPERATURE IS SO STRONG THAT IT'S EASY TO GET CARRIED AWAY...**



CO2 IS THE **DRIVING FORCE** BEHIND THE ICE AGES!

BE CAREFUL, **CORRELATION IS NOT CAUSATION.**

ON THE WALL

PERHAPS THE EXCITABLE KID

**... SO DON'T FORGET WHAT WE LEARNED IN THE LAST CHAPTER.**

THE **MILANKOVITCH CYCLES SET THE TEMPO** FOR THE ICE AGES,...

MM AS A DRUMMER SAYING:

**AS WE'LL SEE IN THE NEXT CHAPTER, HOWEVER, CO2 HAS A MAJOR INFLUENCE ON THE PLANET'S TEMPERATURE,**

**... BUT THE CO2 FEEDBACK LOOP HELPS AMPLIFY THE MESSAGE!**

AND THEN WE SEE THE AMPS AND STUFF IN THE NEXT FRAME AND A SCIENTIST OR SOMEBODY ELSE SAYS:

[AND THEN WE COULD HAVE SMALLISH AMPS LABELED "ALBEDO FEEDBACK" AND MAYBE "ALTITUDE FEEDBACK" AND A REALLY BIG AMP LABELED "CO2 FEEDBACK".

# CHAPTER 5

## ENERGY

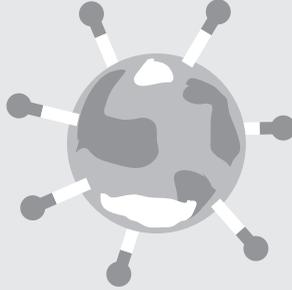
YOUR **BANK ACCOUNT**  
DEPENDS ON **MONEY IN**  
AND **MONEY OUT...**

...AND THE  
**EARTH'S TEMPERATURE**  
DEPENDS ON **ENERGY IN**  
AND **ENERGY OUT.**

PERHAPS BANK TELLER AND  
CUSTOMER DEPOSITING HUGE  
BAG OF MONEY.

**IF YOU SPEND A YEAR MEASURING AIR TEMPERATURES  
ALL OVER THE SURFACE OF THE PLANET...**

GLOBE WITH THERMOMETERS STICKING  
OUT OF IT.



CURRENTLY ABOUT  
**14°C (57°F).**

**... WHAT YOU END UP WITH IS A GLOBAL AVERAGE  
TEMPERATURE FOR PLANET EARTH.**

**IF YOU WANTED TO, YOU COULD  
DO THE SAME THING FOR YOUR HOUSE.**

[MAYBE A KID PUTTING A  
THERMOMETER IN A WEIRD  
PLACE—CEILING? BATHROOM? AND  
THE PARENT ASKS

**WHAT ARE YOU  
DOING?**

MAYBE THE KID SAYS

ABOUT **20°C  
(68°F).**

THE TWO DOMINANT INFLUENCES ON GLOBAL AVERAGE TEMPERATURE ARE **ENERGY IN** AND **ENERGY OUT**.

IT'S TRUE FOR YOUR HOUSE AND IT'S TRUE FOR THE WHOLE PLANET,

WHEN **ENERGY IN** EXCEEDS **ENERGY OUT**, THE PLANET **WARMS UP...**

JUST LIKE YOUR HOUSE WARMS UP WHEN YOU TURN ON THE HEATER,

MAYBE TEENAGE BOY TURNS UP THE HEAT...

...AND WHEN **ENERGY OUT** EXCEEDS **ENERGY IN**, THE PLANET **COOLS DOWN**.

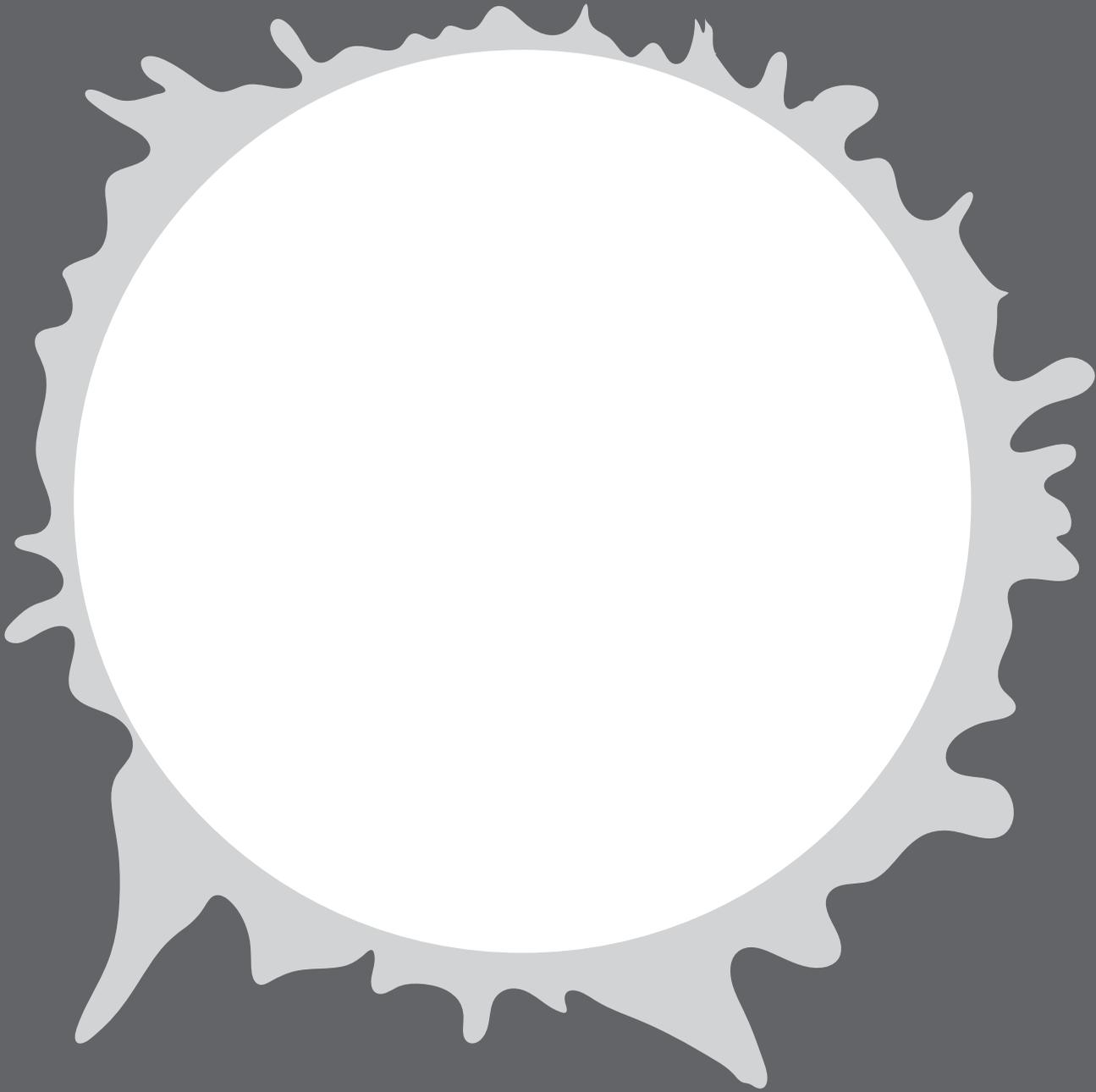
JUST LIKE YOUR HOUSE COOLS DOWN WHEN YOU OPEN A WINDOW,

SHOW ENERGY LEAVING HOUSE

MAYBE TEENAGE GIRL OPENS THE WINDOW, ANNOYING HER BROTHER...

SO TO UNDERSTAND GLOBAL TEMPERATURE WE NEED TO UNDERSTAND MORE ABOUT **ENERGY IN** AND **ENERGY OUT**.

**ENERGY IN IS SIMPLE.**



IF YOU PICTURE  
THE SUN AS A  
**BASKETBALL** ON  
ONE END OF A FULL-  
SIZED COURT...

... THE EARTH  
WOULD BE A **LARGE**  
**GRAIN OF SAND**  
UNDER THE OTHER  
BASKET.

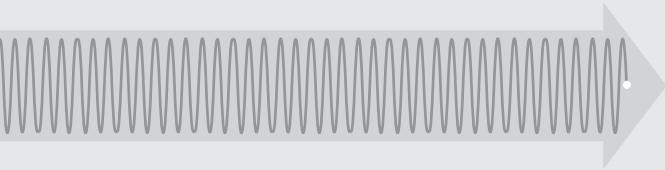
THE AMOUNT OF ENERGY  
HITTING THE EARTH EACH  
SECOND...

... IS EQUIVALENT TO  
EACH PERSON ON  
EARTH RUNNING **100**  
HAIR DRYERS FOR A  
WHOLE YEAR.

HAIR DRYERS COULD FIT  
WITH FAMILY ABOVE,  
TEENAGE BROTHER IS VERY  
ANNOYED AT TEENAGE  
SISTER FOR RUNNING THE  
HAIR DRIER,



**ENERGY FROM THE SUN INCLUDES VISIBLE LIGHT  
AND OTHER TYPES OF ELECTROMAGNETIC RADIATION.**

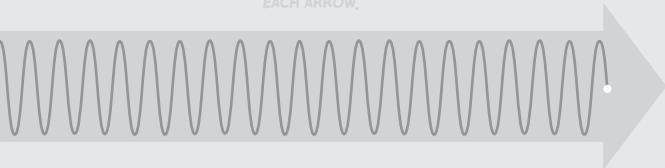


HIGH-ENERGY  
**ULTRAVIOLET**  
(UV) RADIATION  
HAS VERY SHORT  
WAVELENGTHS.

COULD DO A SILLY ICON OR  
SUPERHERO FOR THE DIFFERENT  
KINDS OF RADIATION,

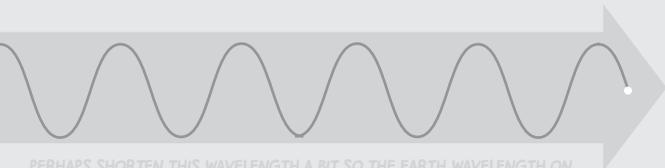
IT'S PARTIALLY  
BLOCKED BY THE  
OZONE LAYER,

PERHAPS A SCIENTIST RIDES  
EACH ARROW,



**VISIBLE LIGHT**  
WAVELENGTHS  
COVER THE WHOLE  
RAINBOW...

... FROM SHORTWAVE  
**VIOLET** TO  
LONGWAVE **RED**,



LOW-ENERGY  
**INFRARED**  
RADIATION HAS  
EVEN LONGER  
WAVELENGTHS,

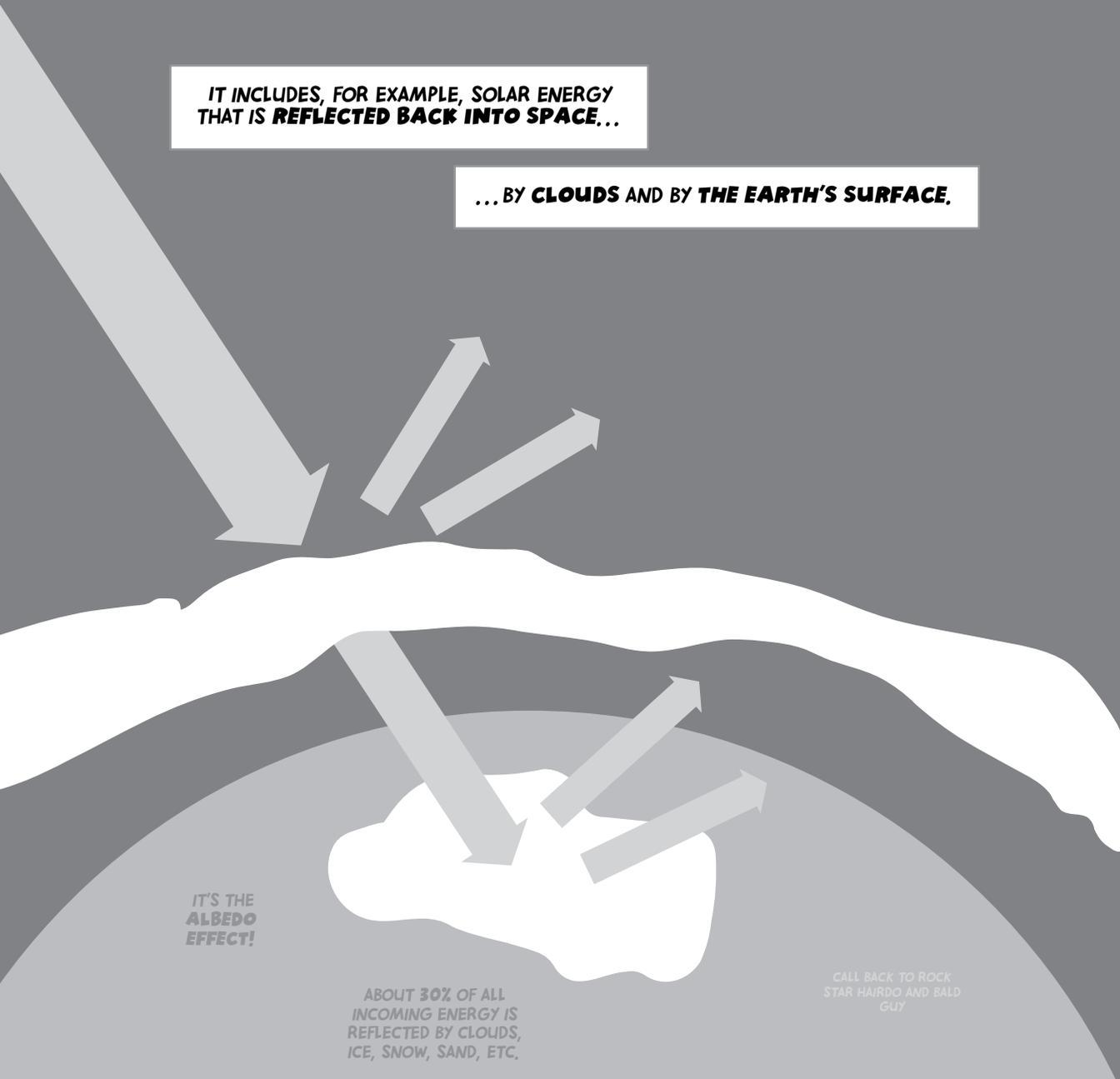
WE'LL COME BACK  
TO THIS IN A  
MOMENT,

PERHAPS SHORTEN THIS WAVELENGTH A BIT SO THE EARTH WAVELENGTH ON  
THE NEXT PAGE CONTRASTS MORE,

**ENERGY OUT IS MORE COMPLICATED.**

**IT INCLUDES, FOR EXAMPLE, SOLAR ENERGY THAT IS REFLECTED BACK INTO SPACE...**

**... BY CLOUDS AND BY THE EARTH'S SURFACE.**



**IT'S THE ALBEDO EFFECT!**

**ABOUT 30% OF ALL INCOMING ENERGY IS REFLECTED BY CLOUDS, ICE, SNOW, SAND, ETC.**

CALL BACK TO ROCK STAR HAIRDO AND BALD GUY

**CHECK OUT THE GLOSSARY FOR MORE.**

INCLUDING THIS TECHNICAL NOTE: IF YOU STUDY MORE CLIMATE SCIENCE, YOU'LL LEARN THAT REFLECTED SOLAR ENERGY IS USUALLY SUBTRACTED FROM ENERGY IN RATHER THAN BEING ADDED TO ENERGY OUT, WE'RE FOLLOWING A MORE INTUITIVE APPROACH, BUT OF COURSE BOTH WAYS ARE CORRECT

CRUCIALLY, ENERGY OUT **ALSO** INCLUDES RADIATION  
GIVEN OFF BY THE EARTH ITSELF.

THE **EARTH** DOESN'T  
EMIT AS MUCH ENERGY  
AS THE **SUN**...

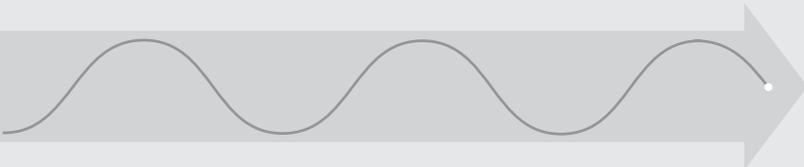
ASTRONAUT HERE



...BUT IT DOES EMIT  
**ENERGY**.

THIS OUTGOING ENERGY IS IN THE **INFRARED** PART OF  
THE ELECTROMAGNETIC SPECTRUM...

ITS WAVELENGTHS ARE  
**LOWER ENERGY** AND  
**LONGER** THAN THOSE  
FROM THE SUN,



CLOSEUP OF  
ASTRONAUT FROM  
THE PANEL ABOVE

...AND IS FAMILIAR TO ANYBODY WHO'S USED **THERMAL IMAGING** EQUIPMENT...

PLUMBER:  
THERE'S A **LEAKY PIPE**  
INSIDE THIS WALL...

POLICE OFFICER:  
... AND A **MAN HIDING** IN YOUR  
**BASEMENT**.

... OR HUDDLED NEAR A **HOT FIRE**.

YOU CAN'T **SEE**  
INFRARED RADIATION,  
BUT YOU CAN **FEEL** IT.

IN THE MORNING IT  
WON'T BE **RED HOT**  
ANYMORE...

...BUT IT WILL STILL BE  
**INFRARED HOT**.

TELLING THIS  
LIKE A GHOST  
STORY

AND THAT BRINGS US TO **GREENHOUSE GASES.**

WATER VAPOR (H<sub>2</sub>O)



CARBON DIOXIDE (CO<sub>2</sub>)



METHANE (CH<sub>4</sub>),



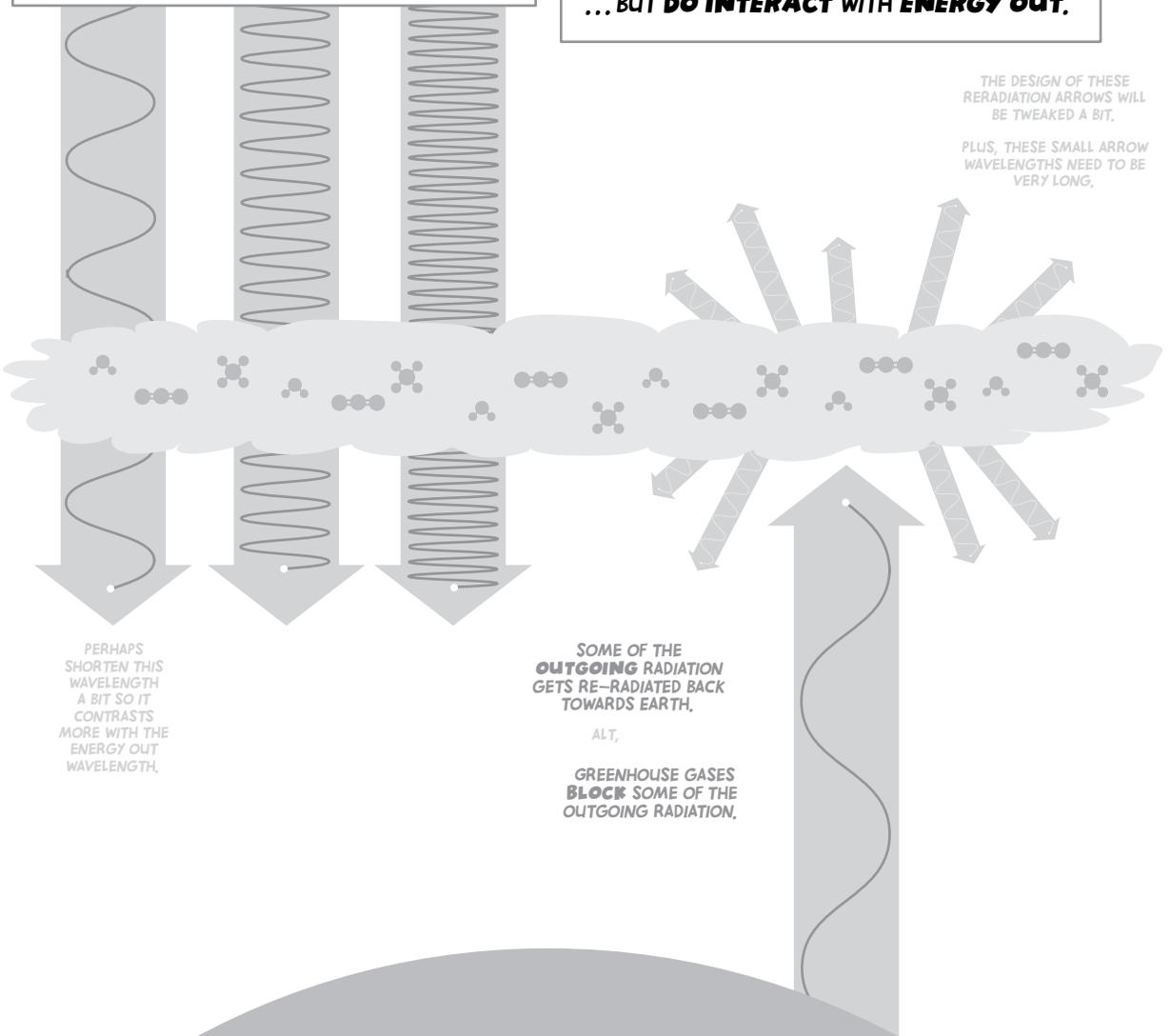
PLUS OTHERS  
THAT ARE LESS  
IMPORTANT.

WHAT MAKES THEM **GREENHOUSE** GASES  
IS THAT THEY **DON'T INTERACT**  
MUCH WITH **ENERGY IN...**

... BUT **DO INTERACT WITH ENERGY OUT.**

THE DESIGN OF THESE  
RERADIATION ARROWS WILL  
BE TWEAKED A BIT.

PLUS, THESE SMALL ARROW  
WAVELENGTHS NEED TO BE  
VERY LONG.



PERHAPS  
SHORTEN THIS  
WAVELENGTH  
A BIT SO IT  
CONTRASTS  
MORE WITH THE  
ENERGY OUT  
WAVELENGTH.

SOME OF THE  
**OUTGOING** RADIATION  
GETS RE-RADIATED BACK  
TOWARDS EARTH.

ALT,

GREENHOUSE GASES  
**BLOCK** SOME OF THE  
OUTGOING RADIATION.

BY REDUCING ENERGY OUT,  
GREENHOUSE GASES **WARM THE PLANET.**

JUST LIKE  
**INSULATION** WARMS  
UP YOUR **HOUSE,**

OR A **BLANKET**  
WARMS UP YOUR  
**BODY.**

WE'D LIKE TO TRY TO THINK  
OF SOMETHING SILLY HERE!

A **GREENHOUSE** ALSO WORKS  
BY **REDUCING ENERGY OUT.**

SEE THE GLOSSARY  
FOR DETAILS.

**IN THE 1800s SCIENTISTS FIGURED OUT THAT THIS **GREENHOUSE EFFECT** HAS A **MAJOR IMPACT** ON THE EARTH'S TEMPERATURE...**

THE **ACTUAL** SURFACE  
TEMPERATURE IS ABOUT  
**14°C (57°F)...**

WEARING EARLY 19TH  
CENTURY VERSION OF  
JEANS

... BUT **WITHOUT**  
**GREENHOUSE GASES** IT  
WOULD BE **-18°C (0°F)**.

WEARING EARLY 19TH  
CENTURY VERSION OF A  
PARKA

**... AND TODAY SCIENTISTS KNOW THAT SIMILAR  
GREENHOUSE EFFECTS EXIST **ON OTHER PLANETS.****

VENUS HAS **70 TIMES**  
MORE ATMOSPHERIC  
CO<sub>2</sub> THAN EARTH...

... AND THAT'S A BIG REASON  
THE SURFACE TEMPERATURE  
(462°C, 863°F) IS HOT ENOUGH  
TO **MELT LEAD!**

THE GREENHOUSE EFFECT ON VENUS IS OF COURSE  
**NOT CAUSED BY HUMANS...**

OR BY  
**MARTIANS!**

OR BY  
**PREHISTORIC  
GIANTS!**

MARTIAN HERE,

GEOLOGIST  
HERE, OR  
GIANT.

... AND WE'VE ALREADY SEEN THAT THERE'S  
**A NATURAL GREENHOUSE EFFECT ON EARTH TOO.**

DURING THE **ICE AGES**,  
CO<sub>2</sub> LEVELS VARIED BETWEEN  
ABOUT **180PPM**  
AND **280PPM...**

... AND DURING **HOTHOUSE  
EARTH PERIODS**, THEY WERE  
**MUCH MUCH HIGHER.**

HAVE WE REALLY GOTTEN THE IDEA OF PPM  
ACROSS BY THIS POINT? JUST ASKIN.

VISUAL CALLBACK TO HOTHOUSE EARTH IMAGE  
FROM CHAPTER 2.

**BUT WE'VE ALSO SEEN THAT HUMANS HAVE BEEN  
ADDING LOTS OF GREENHOUSE GASES TO THE ATMOSPHERE.**

SINCE THE START OF THE  
**INDUSTRIAL REVOLUTION IN**  
THE LATE 1700s...

... WE'VE INCREASED CO<sub>2</sub> LEVELS  
**TO 400PPM.**

THE SWEDISH CHEMIST **ARRHENIUS** WAS ONE OF THE FIRST TO RECOGNIZE THAT **HUMANS WERE BOOSTING THE GREENHOUSE EFFECT.**

THE DRAWING WILL SHOW THAT HE WAS IN THE LATE 1800S, (WITH HIS CLOTHES, AND MAYBE A FARMER WITH A HORSE.)

THIS IS GOING TO BE GREAT FOR FARMERS IN SWEDEN!

IN 1896 HE STUDIED WHAT WOULD HAPPEN IF WE **DOUBLED** CO<sub>2</sub> CONCENTRATIONS...

... AND MADE A ROUGH CALCULATION OF THE **EVENTUAL INCREASE IN GLOBAL AVERAGE TEMPERATURE.**

WHAT IF WE WENT FROM **280 PPM...**

... TO **560 PPM?**

LOTS AND LOTS AND LOTS OF PAPERS WITH A PENCIL SCRIBBLING FURIOUSLY

ABOUT **5°C (9°F).**

[HE'S GOT REAMS OF PAPER AND A PENCIL]

PERHAPS CRAWLING OUT FROM UNDER THE HUGE PILE OF PAPERS,

HIS ESTIMATE FROM 1896 CAME **REMARKABLY CLOSE** TO THE RANGE THAT CLIMATE SCIENTISTS TALK ABOUT TODAY.

THEY'VE GOT ALL THESE FANCY COMPUTERS

ABOUT **2-4°C (3.6-7.2°F).**

# CHAPTER 6

## SCIENCE

WHY SHOULD I  
TRUST ~~you~~?

(ARRHENIUS, HERE, CARRY OVER  
FROM THE PREVIOUS PAGE)

**DON'T TRUST US.**

THIS COULD BE THE DETECTIVE'S  
LINE, IF HE'S A BIT SHADY.

(CLIMATE SCIENTIST FROM  
THE BOTTOM OF PREVIOUS  
PAGE):

**TRUST THE  
SCIENTIFIC  
METHOD.**

NANCY DREW, SHERLOCK HOLMES, POLICE DETECTIVES, THAT SORT OF THING, WE  
COULD POTENTIALLY INTRODUCE THIS THEME ON THE INTRO PAGE OF THE CHAPTER,

DEPENDS ON HOW THE DRAWING GOES, MAYBE A CHARACTER WILL POP OUT.

**THE SCIENTIFIC METHOD INVOLVES  
DEVELOPING HYPOTHESES...**

NEWTON UNDER THE APPLE  
TREE, MAYBE WITH  $F=MA$   
OR  $F=GM \frac{M}{R^2}$ .

**... TESTING THOSE HYPOTHESES  
AGAINST THE REAL WORLD...**

ASTRONAUT:

NEWTON'S THEORY  
OF GRAVITY WORKS  
**ON THE MOON!**

BUT WITH THINGS LIKE **GPS**  
IT'S A LITTLE BIT OFF.

FANCY  
SATELLITE

**... AND THEN *REFINING* THEM *BASED ON THE DATA.***

EINSTEIN, WITH A BLACKBOARD BEHIND HIM THAT HAS  $E=MC$ ,  
 $E=MC^2$ , AND  $E=MC^3$ , WITH THE SECOND CIRCLED AND THE  
OTHERS CROSSED OUT.

AT **SUPER HIGH SPEEDS,**  
**EINSTEIN'S THEORY**  
WORKS BETTER THAN  
**NEWTON'S.**

**THIS PROCESS NEVER ENDS...**

**EVEN EINSTEIN COULDN'T  
UNITE GRAVITY AND  
QUANTUM MECHANICS.**

PERHAPS ON THE CHALKBOARD  $E=MC^2$   
ON ONE SIDE AND SOME QUANTUM  
SQUIBBLES ON THE OTHER, WITH A GAP  
IN THE MIDDLE AND A STUMPED EINSTEIN  
HOLDING HIS HEAD IN HIS HANDS.

NOT SURE, AND I'M NOT INSPIRED  
AT THE MOMENT, BUT I HOPE THIS  
PHILOSOPHICAL TYPE MATERIAL CAN  
FEEL AS VISCERAL AND IMMEDIATE AS  
POSSIBLE.

THIS IS A LITTLE QUIBBLE, MAYBE WE'LL  
GET BACK TO IT, MAYBE NOT...  
BUT MENTIONING QUANTUM FEELS A  
BIT BRAINY TO ME AND I WONDER IF WE  
COULD SAY SOMETHING THAT INCLUDES  
THE FACT THAT OUR DESCRIPTIONS OF  
BIG THINGS DON'T OVERLAP WITH OUR  
DESCRIPTIONS OF REALLY TINY THINGS...

NOT SURE, AND I'M NOT INSPIRED  
AT THE MOMENT, BUT I HOPE THIS  
PHILOSOPHICAL TYPE MATERIAL CAN  
FEEL AS VISCERAL AND IMMEDIATE AS  
POSSIBLE.

**... AND IT NEVER PRODUCES "ABSOLUTE TRUTH"...**

(JUMPER1):

**THE THEORY OF  
GRAVITY IS JUST  
A THEORY.**

**... BUT THE SCIENTIFIC METHOD REMAINS ONE OF HUMANITY'S  
MOST POWERFUL INVENTIONS**

(JUMPER2):

**IT'S THE BEST THING  
TO LOOK AT BEFORE  
YOU LEAP.**

**THE IDEAL WAY TO TEST A HYPOTHESIS IS WITH A CONTROLLED EXPERIMENT...**

KID'S SCIENCE PROJECT WITH PLANTS

**I GAVE LOTS OF WATER TO THESE PLANTS...**

**... AND NO WATER TO THESE ONES,**

**LET'S SEE WHICH ONES SURVIVE,**

MEDICINE TESTING:

**I GAVE CHILLAXITROL TO THESE HYPERACTIVE KIDS...**

*I'D PREFER SOMETHING FUNNIER THAN DIABETICS,*

**... AND NOT TO THESE ONES,**

**LET'S SEE WHICH ONES CAN CONCENTRATE BETTER.**

PERHAPS ADD:

**I GAVE THE CARTOON INTRODUCTION TO CLIMATE CHANGE TO THESE STUDENTS...**

**... AND NOT TO THESE ONES,**

**LET'S SEE WHO DOES BETTER ON THE TEST!**

**... BUT THAT'S NOT ALWAYS POSSIBLE,**

FOR EXAMPLE, YOU CAN'T DO **CONTROLLED EXPERIMENTS** ABOUT **SMOKING**...

I GAVE **ADDICTIVE NICTONE STICKS** TO THESE KIDS...

... AND NOT TO THESE ONES,

EVIL MAD SCIENTIST,

... OR ABOUT **CLIMATE CHANGE**.

I **DOUBLED THE CO2** ON THIS PLANET...

... AND NOT ON THIS ONE,

EVIL ALIEN TYRANT,

**SCIENTISTS HAVE NONETHELESS MADE PROGRESS ON THESE ISSUES.**

IN FACT, THE SCIENTIFIC HISTORIES OF **SMOKING** AND **CLIMATE CHANGE** ARE SIMILAR.

WHAT POSSIBLE SIMILARITIES COULD THERE BE?

PERSON SMOKING ON A DIRTY MOTORCYCLE,

**THE SCIENTIFIC LINK BETWEEN *SMOKING* AND *CANCER* HAS GROWN STRONGER AND STRONGER OVER TIME...**

1957:

THE WEIGHT OF THE EVIDENCE [SUGGESTS] THAT EXCESSIVE SMOKING IS ONE OF THE CAUSATIVE FACTORS IN LUNG CANCER,

1964:

CIGARETTE SMOKING IS **CAUSALLY RELATED** TO LUNG CANCER **IN MEN**,

2004:

25 MILLION AMERICANS ALIVE TODAY WILL MOST LIKELY DIE OF A SMOKING-RELATED ILLNESS,

SURGEONS GENERAL FROM DIFFERENT YEARS,

PERHAPS PRESS CONFERENCE WITH SIGN ON PODIUM THAT SAYS THE DATES,

**... AND A SIMILAR TREND IS EVIDENT IN THE SCIENTIFIC LINK BETWEEN *GREENHOUSE GAS EMISSIONS* AND *CLIMATE CHANGE*.**

IPCC 1995:

THE BALANCE OF EVIDENCE SUGGESTS A DISCERNABLE HUMAN INFLUENCE ON GLOBAL CLIMATE,

IPCC 2001:

THERE IS NEW AND STRONGER EVIDENCE,

IPCC 2013:

IT IS **EXTREMELY LIKELY** THAT HUMAN ACTIVITIES HAVE CAUSED **MORE THAN HALF** OF THE OBSERVED INCREASE IN GLOBAL AVERAGE SURFACE TEMPERATURE SINCE THE 1950S,

PERHAPS SPELL OUT IPCC, OR JUST EXPECT PEOPLE TO LOOK IN THE GLOSSARY WHEN THEY SEE "IPCC":

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

**SOME OF THE BEST EVIDENCE COMES FROM CLIMATE SCIENTISTS' SUCCESSFUL PREDICTIONS FROM DECADES PAST.**

WE PREDICT THAT RISING TEMPERATURES WILL BECOME **OBVIOUS** BY THE TURN OF THE CENTURY.

OUR **FASHION SENSE** WAS **TERRIBLE...**

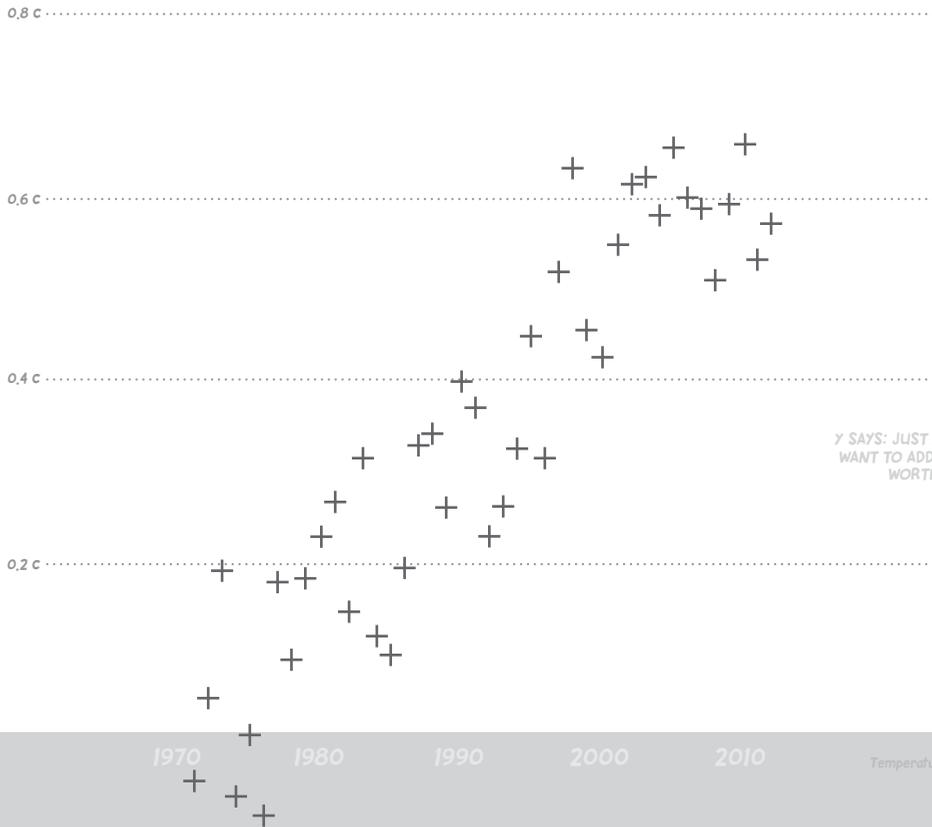
... BUT OUR PREDICTIONS WERE **GREAT.**

(1970S SCIENTISTS, IN 1970S CLOTHES AND GLASSES AND HAIRSTYLES: AFROS AND BEARDS &C):

**SINCE THE 1970S, GLOBAL TEMPERATURE INCREASES HAVE AVERAGED ABOUT 0.15C (0.3F) PER DECADE.**

WE PREDICTED **0.2C (0.4F)...**

... NOT BAD!



Y SAYS: JUST A NOTE THAT WE MIGHT WANT TO ADD A FEW MORE DECADES' WORTH OF DATA HERE.

Temperatures relative to 20th century average.

**AND CLIMATE SCIENTISTS HAVEN'T JUST BEEN  
RIGHT ABOUT THE BIG PICTURE...**

SCIENTIST FANNING SELF AND SWEATING.

THE COOK HAD ACCESS TO THE MURDER  
WEAPON,

D2: EVERYONE KNEW SHE HATED HIM,

(ALT: SHE WAS ALWAYS TALKING ABOUT HOW  
MUCH SHE LOATHED/HATED HIM, )

D3: NOBODY ELSE WAS IN THE KITCHEN THAT  
MORNING,

D4 (OPTIONAL, BY THE COOK): IT WASN'T  
ME, IT WAS QUEEN VICTORIA,

**... THEY'VE ALSO BEEN RIGHT  
ABOUT LOTS OF THE DETAILS.**

MORE WARMING  
AT **NIGHT** THAN  
DURING THE  
**DAY?**

YUP,

MORE WARMING  
**NEAR THE POLES**  
THAN **NEAR THE**  
**EQUATOR?**

YUP,

OLD BRAINSTORMS:

SOMETHING FUNNY LIKE,

MORE WARMING ON MY HAIRY  
HEAD...

THAN ON MY BALD ONE?

OR A GAG ABOUT THEIR FASHION,

**LESS ENERGY**  
ESCAPING INTO THE  
**STRATOSPHERE**  
AND INTO **SPACE?**

YUP,

**THOSE DETAILS ARE LIKE FINGERPRINTS AT A CRIME SCENE.**

D (DETECTIVE):

PEERING AT A  
THERMOMETER  
PERHAPS?

OR MAYBE STANDING  
ON A BLOCK OF ICE  
FLOATING IN THE SEA  
AND EXAMINING IT  
WITH A MAGNIFYING  
GLASS.

THIS HAS GOT  
**ANTHROPOGENIC**  
**GLOBAL WARMING**  
WRITTEN ALL OVER IT.

**DETECTIVE WORK IS ACTUALLY  
A PRETTY GOOD ANALOGY...**

UP HERE,

THE CONCLUSION IS  
**INESCAPABLE,**

IT WASN'T ME,  
IT WAS **QUEEN  
VICTORIA,**

**ONLY ONE PERSON**  
HATES THE BUTLER,..

... **AND** HAS KEYS  
TO THE KITCHEN,..

... **AND** KNOWS HOW  
TO MAKE A SOUP THIS  
DELICIOUS,

FOOTMAN HERE,  
OBSERVING THE  
LEGS OF THE  
BUTLER, WHICH ARE  
STICKING UP OUT  
OF A POT,

DEAD BUTLER HERE, HIS FEET STICK  
OUT OF A POT,

DETECTIVE, PULLS A LADLE  
OUT OF THE POT AND  
TASTES IT...

COOK HERE,

ALT:

TURKEY DEATH  
... **AND** KNOWS HOW TO  
TRUSS A TURKEY,

**... AND 100 YEARS OF SCIENTIFIC DETECTIVE WORK HAS CONVINCED MOST SCIENTISTS  
THAT GREENHOUSE GAS EMISSIONS ARE WARMING THE PLANET.**

**WE'RE  
CONVINCED.**

**WE'RE NOT.**

2 MICROPHONES HERE, THERE'S AN INCREDIBLE LINE OF LAB COATED SCIENTISTS BEHIND ONE  
MICROPHONE AND THERE'S TWO SCIENTISTS BEHIND THE OTHER MICROPHONE.

THIS ON JACKETS

**IPCC  
AAAS  
AMS  
ACS  
ASA**

THIS ON JACKET  
**NIPCC**

THIS ON SIGN IN FRONT OF  
CHARACTERS WITH DISTINCTIVE DRESS:

**National Academies of Sciences**

IPCC = INTERGOVERNMENT PANEL ON CLIMATE CHANGE; AAAS = AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE; AMS = AMERICAN METEOROLOGICAL SOCIETY; ACS = AMERICAN CHEMICAL SOCIETY;  
ASA = AMERICAN STATISTICAL ASSOCIATION; NIPCC = NONGOVERNMENTAL INTERNATIONAL PANEL ON CLIMATE CHANGE

INCLUDES THE NATIONAL ACADEMIES OF THE U.S., BRAZIL, CANADA, CHINA, FRANCE, GERMANY, INDIA, ITALY, JAPAN, RUSSIA, THE U.K., AUSTRALIA, BELGIUM, THE CARRIBEAN, INDONESIA, IRELAND, MALASIA, NEW ZEALAND, SWEDEN.

OF COURSE, IT'S ALWAYS POSSIBLE THAT ALL THOSE SCIENTISTS ARE **WRONG**.

WHOOPS, **GLOBAL WARMING** IS ACTUALLY CAUSED BY **BROCCOLI...**

...AND SO IS **LUNG CANCER**.

AND THE KILLER REALLY WAS **QUEEN VICTORIA!**

IN A BAR, WITH DRINKS IN FRONT OF THEM,

SMOKING

DETECTIVE AT THE SAME BAR, PERHAPS WITH QUEEN VICTORIA IN HANDCUFFS, BUT I DOUBT IT.

BUT SO FAR **NOBODY** HAS BEEN ABLE TO IDENTIFY A **GOOD COMPETING THEORY** FOR GLOBAL WARMING...

IS IT CAUSED BY **SUNSPOTS?**

NO.

**EL NINO?**

NO.

**MILANKOVITCH CYCLES?**

NO.

**BROCCOLI?**

WHA?

GO THROUGH SOME OF THE COMPETING THEORIES:

KIDS

DETECTIVE CHARACTER INVOLVED HERE.

... AND THE CASE FOR **ANTHROPOGENIC CLIMATE CHANGE** HAS GOTTEN **STRONGER AND STRONGER**.

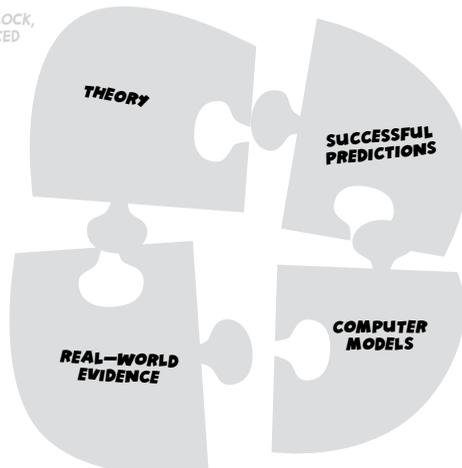
I'LL DRAW THIS BY HAND, AND THE PIECES WILL INTERLOCK, WITH THE REAL WORLD EVIDENCE PIECE BEING PLACED DOWN WITH THE OTHERS.

D (DETECTIVE):

IT'S ALL **COMING TOGETHER**.

I CAN DEFINITELY HAVE THE PIECES BLEED OFF THE PAGE, AND HAVE LOTS MORE OF THEM.

THAT'S DRAWING HEAVY WORK, SO I'LL POSTPONE IT.



**MOST GLOBAL WARMING DATA IS GATHERED BY SCIENTISTS...**

**FROM SPACE,**

I'LL DRAW A SATELLITE HERE

**IN THE OCEANS,**

I'LL DRAW AN OCEAN BOUY HERE

**ON LAND,**

I'LL DRAW A SCIENTIST STANDING ON LAND AND DRILLING INTO A GLACIER HERE.

**... BUT IN FACT, THERE'S EVIDENCE OF GLOBAL WARMING ALL AROUND US.**

**FLOWERS ARE BLOOMING EARLIER.**

**BIRDS ARE MIGRATING EARLIER.**

**ALLERGY SEASON IS STARTING EARLIER.**

THIS IS THE SAME GRANDPARENT IN THE PANEL BELOW.

MAN WITH HUGE BOX OF KLEENEX AND KLEENEXES ALL OVER THE GROUND.

**YOU MIGHT EVEN FIND PHENOLOGICAL EVIDENCE IN YOUR OWN BACKYARD.**

[OR YB COULD FIND AN ACCURATE DATE HERE,] **A PIED FLYCATCHER, AND IT'S ONLY APRIL 10!**

**SOME BIRDS HAVE A NATURAL INSTINCT TO MIGRATE...**

AND THEN A SCIENTIST STUDYING THE HUMANS:

**... AND SOME HUMANS HAVE A NATURAL INSTINCT TO KEEP RECORDS.**

ONE GRANDPARENT BIRDWATCHER

HER HUSBAND.

THIS ON A PIN OR A BUMPER STICKER OR SOMETHING.

**THESE DAYS, MUCH OF WHAT WE KNOW ABOUT CLIMATE CHANGE IS INCORPORATED INTO **COMPUTER MODELS...****

I LOVE THIS:

ANOTHER FUN BRAINSTORM HERE COULD BE A BIG SIPHON CONNECTED TO AN ELECTRICAL CABLE, I.E., WE'RE TAKING THE BIRDS AND THE ICE SHEETS AND THE THEORETICAL EQUATIONS AND THE MILANKOVITCH CYCLES AND STUFFING THEM ALL INTO THIS GRINDER THAT IS CONNECTED TO A COMPUTER, AND THEN MAYBE WE COULD MOVE THE "OVERHEATED COMPUTER SHOWING AN OVERHEATED PLANET" IDEA DOWN TO THE BOTTOM OF THE PAGE.

Y FUN BRAINSTORM:

MAYBE WE COULD HAVE AN "OVERHEATING" COMPUTER THAT'S DISPLAYING A SCREEN IMAGE OF AN "OVERHEATING" PLANET?

**... WHICH DO A PRETTY GOOD JOB OF SIMULATING EVERYTHING FROM THE **ICE AGES...****

CHECK OUT **CHAPTER 3.**

**... TO **VOLCANIC ERUPTIONS.****

**SHORT-TERM COOLING FOR A FEW YEARS, BUT NO LONG-TERM IMPACT.**

VOLCANO HERE.

**THESE COMPUTER MODELS PROVIDE THE BEST INDICATION OF WHAT'S COMING **IN THE DECADES AHEAD.****

THE COMPUTER IS GETTING OVERHEATED HERE... PERHAPS A CHARACTER SAYS, **\*\*\$\$&**

"YORAM PREFERS SOMETHING MORE NEUTRAL LIKE: **HEADS UP!**

WE WANT TO EMPHASIZE THIS, PERHAPS WITH A FINAL NARRATOR PANEL, THAT HAS THEM BITING THEIR TEETH (SIMILAR GESTURES TO "ABOUT THAT HEATING OIL.")

**PART  
TWO**  
*PREDICTIONS*



# **CHAPTER 7**

## **GLOBAL WARMING**

*NIX THESE DS; WE'LL HAVE TO COME UP WITH SOME OTHER OPENING GAG. MAYBE THE 5 CHARACTERS ARE IN A TRAIN AND THEY'RE SHOVELING COAL INTO THE ENGINE AND SWEATING AND SAYING*

***IS IT JUST ME... OR IS IT GETTING HOT IN HERE?!***

*PS, I VOTE NO ON TWO OF THE NOTES BELOW: I DON'T THINK WE SHOULD CALL THE TRAIN B&U, AND I'M NOT KEEN ON THE TIED-TO-THE-TRACKS IDEA. (TOO FATALISTIC IMHO.)*

*A TRAIN COMING DOWN THE TRACKS, LETTING OUT STEAM*

NOW THAT WE'VE COVERED THE  
**BASIC SCIENCE OF CLIMATE CHANGE...**

... LET'S TAKE A LOOK AT **WHAT MIGHT HAPPEN.**

THESE TWO PANELS COULD FEATURE A  
SCIENTIST LOOKING INTO A MICROSCOPE ON  
THE LEFT AND A SCIENTIST LOOKING INTO A  
CRYSTAL BALL ON THE RIGHT.

THEN IN PART III WE'LL  
LOOK AT **WHAT WE  
CAN DO ABOUT IT.**

OF COURSE, LOTS OF THINGS **COULD**  
HAPPEN IN THIS CENTURY AND BEYOND.

WE COULD DEVELOP  
**COLD FUSION...**

...OR **CARBON-EATING  
TREES...**

...OR **FLYING  
WINDMILLS...**

...OR **PERPETUAL  
MOTION MACHINES!**

ASIDE, WHISPERED:

ACTUALLY, THAT ONE  
**COULDN'T HAPPEN;**  
IT'S **IMPOSSIBLE.**

**ONE ~~VERY UNLIKELY~~ POSSIBILITY IS THAT HUMAN CARBON EMISSIONS WILL STOP ~~COLD TURKEY~~.**

YOU CAN IGNORE THIS COMMENT IF YOU WANT, BUT I'M GOING TO GIVE CONTINUAL PUSH-BACK ABOUT ASSOCIATING HUMAN CARBON EMISSIONS WITH DRIVING AND GASOLINE. THAT'S WHAT EVERYBODY THINKS, BUT IT'S MUCH MORE ABOUT COAL AND ELECTRICITY.

SO IF I HAD MY DRUTHERS THIS WOULD BE A SCENE INSIDE A HOUSE, WITH ALIENS TELLING PEOPLE TO SHUT EVERYTHING DOWN, AND MAYBE THERE'S A WINDOW AND THROUGH THE WINDOW YOU CAN SEE A CAR AND AN ALIEN JUMPING ON THE HOOD OR PULLING PEOPLE OUT OF THE CAR OR STANDING IN FRONT OF THE CAR WITH A STOP SIGN OR SOMETHING ELSE FUN :) AND/OR MAYBE THEY'RE PUTTING A COVER ON A POWER PLANT EXHAUST STACK :)

YORAM, I'M THE ONE ARGUING TO TO ATTACH HUMAN EMISSIONS WITH COAL AND ELECTRICITY, (ALL SORTS OF DAY TO DAY ACTIVITIES), SO YOU DON'T GET TO ARGUE FOR IT :-)

THAT'S IT,  
PARTY'S OVER.

SHUT EVERYTHING DOWN  
**RIGHT NOW.**

**A MUCH MORE LIKELY POSSIBILITY IS THAT DEVELOPING COUNTRIES LIKE CHINA AND INDIA WILL FOLLOW THE PATH BLAZED BY DEVELOPED COUNTRIES LIKE THE U. S.**

**FOSSIL FUELS TO POWER HOMES, FACTORIES, AND MOTOR VEHICLES...**

...AND **DEFORESTATION** TO CLEAR LAND FOR FARMS, ROADS, AND BUILDINGS.

**WE CALL THIS PATH BUSINESS AS USUAL.**

WHAT IF WE **DIDN'T DO MUCH** TO REDUCE CARBON EMISSIONS?

THAT WOULD BE **BUSINESS AS USUAL.**

**THE KEY FACT ABOUT  
BUSINESS AS USUAL  
IS THAT IT WOULD MAKE  
CO2 EMISSIONS EXPLODE.**

MAYBE AN OVERLOADED 3RD WORLD TYPE TRUCK DRIVES ONTO THE  
PANEL AT THE LEFT AND THEN RIGHT ABOUT HERE EXPLODES, SENDING  
THE PASSENGERS FLYING AROUND?

OR SOME OTHER SILLY AND SIMPLE EXPLOSION.

THE TRUCK COULD FIRST APPEAR ON THE PREVIOUS PAGE.

ALTERNATELY, A BOMB IS LIT ON THE PREVIOUS PAGE, OR SOMETHING  
ELSE THAT'S SENSITIVE TO HUMAN LIFE :-)

**TO SEE WHY, LET'S DIVIDE THE WORLD'S 7 BILLION PEOPLE INTO  
FIVE CHINA-SIZED CHUNKS.**

SITTING DOWN TO A TABLE, WITH PLACECARDS THAT  
SAY:

RICH WORLD  
CHINA  
INDIA  
REST OF ASIA  
EVERYONE ELSE

**1.4 BILLION  
NAPKINS, PLEASE.**

MAITRE D TO WAITER.

**THE RICH WORLD MAKES UP JUST ONE OF THOSE FIVE CHINAS...**

5 TABLES HERE, WITH THE RICH WORLD HIGHLIGHTED  
SOMEHOW... THIS IS JUST A SETUP FOR THE NEXT  
PANEL'S WONDERFUL GAG.

**... BUT AT THE START OF THE 21ST CENTURY IT WAS RESPONSIBLE FOR ABOUT  
HALF OF THE WORLD'S FOSSIL FUEL CONSUMPTION.**

ONE CAKE IN FRONT OF THE RICH, AND ONE CAKE IN FRONT OF THE  
REST... (A WHOLE CAKE, IN THE PROCESS OF BEING DELIVERED.)

Y FEELS IT'S IMPORTANT THAT THE WAITER SAYS THIS LINE:

ONE CAKE FOR  
**you...**

**... YOU ALL CAN SHARE  
THE SECOND CAKE.**

**UNDER BUSINESS AS USUAL, THE OTHER FOUR  
CHINAS COULD **CATCH UP** BY 2100.**

THANKS TO RAPID  
ECONOMIC GROWTH...

... WE CAN NOW AFFORD  
**MORE CAKE!**

D (MAYBE  
WAITER?):

**THAT'S 150%  
MORE CAKE.**

A BAKER DELIVERS 3 MORE CAKES FOR A TOTAL OF 5 AT THE TABLE,  
IE, WE USED TO HAVE 2 CAKES, NOW WE HAVE FIVE.

**MEANWHILE, POPULATION GROWTH IS LIKELY TO  
ADD ANOTHER 2 CHINAS TO THE PLANET.**

WE'RE GOING TO  
NEED **TWO MORE**  
PLACE SETTINGS,

**NOW IT'S 250%  
MORE CAKE.**

A BAKER DELIVERS 2 MORE CAKES FOR A  
TOTAL OF 7 IN THIS PANEL,

TWO MORE DINERS, WAITER PUTS IN FRONT OF THEM TWO  
MORE PLACECARDS THAT SAY:

**AFRICA**

AND

**MORE ASIA**

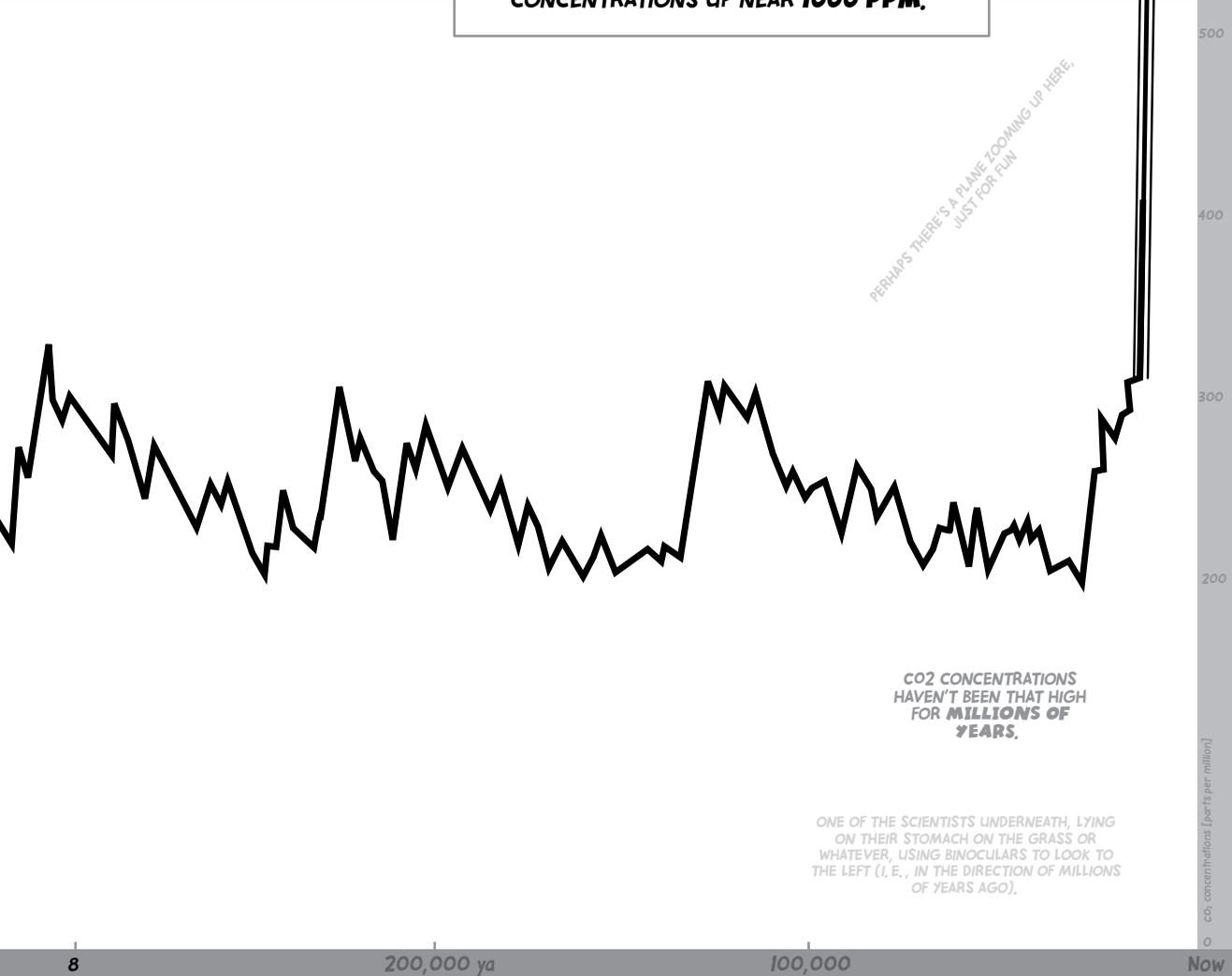
**SURE ENOUGH, BUSINESS AS USUAL EMISSIONS ARE PROJECTED TO RISE ABOUT 250% OVER THE COURSE OF THIS CENTURY...**

THE CHINA CHARACTERS ARE DRIVING CARS, AND USING THE DISHWASHER AND ETC.

PERHAPS CONTRIVE A WAY TO TIE THESE IN WITH THE GRAPHS ON CHAPTER 4 PAGE 8... MAYBE THE BEST WAY TO DO THAT IS JUST WITH A DRAWING.



**... PUSHING ATMOSPHERIC CO2 CONCENTRATIONS UP NEAR 1000 PPM.**



PERHAPS THERE'S A PLANE ZOOMING UP HERE, JUST FOR FUN

CO2 CONCENTRATIONS HAVEN'T BEEN THAT HIGH FOR **MILLIONS OF YEARS.**

ONE OF THE SCIENTISTS UNDERNEATH, LYING ON THEIR STOMACH ON THE GRASS OR WHATEVER, USING BINOCULARS TO LOOK TO THE LEFT (I.E., IN THE DIRECTION OF MILLIONS OF YEARS AGO).

900  
800  
700  
600  
500  
400  
300  
200  
0  
CO2 concentrations (part's per million)  
Now

8 200,000 ya 100,000

WORDSMITH, I DON'T LIKE THIS ASSIVE LANGUAGE, HOW ABOUT SOMETHING LIKE "AS A RESULT, BY 2100, GLOBAL TEMPERATURES WILL LIKELY BE ABOUT 4C HIGHER," OR: "WHICH MEANS WE SHOULD EXPECT GLOBAL TEMPERATURES TO RISE ABOUT 4C IN THE NEXT CENTURY."

**THE RESULTING GLOBAL TEMPERATURE CHANGE BY 2100 IS LIKELY TO BE ABOUT 4C (7F).**

FORTUNE TELLER IMAGE HERE, RECALLS PICTURE AT THE TOP OF CHAPTER I



I WONDER IF THERE'S SOME WAY TO USE THE CRYSTAL BALL A BIT MORE CLEVERLY HERE, WITH A DRAWING INSIDE IT OF PEOPLE SWEATING OR SOMETHING... ON THE OTHER HAND WE WANT TO USE THE NUMBER TO GOOD EFFECT TOO, SO I'LL PLAN TO PLAY AROUND WITH IT IN LAYOUTS.

ALT; THEY COULD RISE A BIT LESS... OR A BIT MORE...

**IT COULD BE A BIT LESS...**

FORTUNE TELLER WAFFLES HERE, **MAYBE ONE DEGREE LESS.**

**...IT COULD BE MORE...**

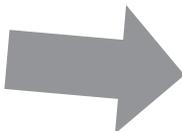
MAYBE AS MUCH AS **TWO OR THREE DEGREES MORE.**

MEH.

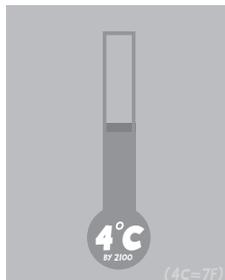
WE'LL COME BACK TO **UNCERTAINTY** IN **CHAPTER II.**

**... BUT THIS NUMBER MAKES A GOOD STARTING POINT FOR UNDERSTANDING THE CHANGES THAT ARE COMING.**

THREE SCIENTISTS HOLD THESE THREE THINGS,



THEN ON THE SPREAD AFTER NEXT, THIS CAN TURN OUT TO BE A BOOK,



MAYBE USE THE THERMOMETER IMAGE IN THE PICTURES SOMEWHERE, PERHAPS HERE,

IT MIGHT BE TEMPTING TO THINK OF **4C**  
AS **NO BIG DEAL...**

WINTERS WILL BE A BIT WARMER,  
SO I'LL **PAY LESS** FOR  
HEATING...

... AND SUMMERS WILL  
BE A BIT WARMER, SO I'LL  
**PAY MORE** FOR AIR  
CONDITIONING.

WHY ALL THE  
**FUSS?**

... OR, ALTERNATELY, AS A **BIG BIG DEAL...**

IN MOST PLACES, THE  
**AVERAGE SUMMER IN 2100...**

... WILL BE **HOTTER THAN THE  
HOTTEST SUMMER OF THE  
20TH CENTURY.**

... **BUT NEITHER OF THESE IS THE BEST WAY TO THINK ABOUT IT.**

THE TWO PEOPLE FROM THE FRAMES ABOVE  
(PRESUMABLY A SKEPTIC-ISH PERSON  
AND AN ALARMIST-ISH PERSON) BEING  
QUIZZICAL:

HUH?

HOW ABOUT IN THIS FRAME THE NARRATOR  
SCIENTIST PREPARES TO OPEN IT...

**4°C**  
BY 2100

THE **BEST** WAY TO THINK ABOUT 4C IS AS A KIND OF **SHORTHAND**.

IT'S LIKE THE **TITLE**  
OF A **BOOK**...

...AND YOU SHOULD BE  
CAREFUL ABOUT **JUDGING A**  
**BOOK BY ITS COVER**.



BOOK WITH 4 ON IT.

THERE ARE LOTS OF OTHER  
**CLIMATE-RELATED SHORTHANDS**...

TITLES ON SPINES:

350 PPM  
600PPM  
1000 PPM  
RCP 2,6  
RCP 4,5  
RCP 6,0  
RCP 8,5  
COLD TURKEY  
WARM TURKEY  
GOOSE EGG  
CHICKEN LITTLE  
FOWL WEATHER (!)

...AND ALL OF THEM ATTEMPT TO SUMMARIZE  
**LOTS OF DIFFERENT CHANGES IN LOTS OF DIFFERENT PLACES**.

READ ME THE CHAPTER  
ABOUT **SEA LEVEL**  
**RISE IN ASIA**.

ONE CHAPTER A NIGHT AND  
WE'LL BE DONE BY THE TIME  
YOU **GO TO COLLEGE**.



BOOK WITH 4 ON IT.

PARENT READING  
TO SMALL CHILD AT  
NIGHT TIME;

OPENING UP THE  
BOOK HERE.

FOR EXAMPLE, A GLOBAL INCREASE OF 4C (7F) WOULD LIKELY WARM OCEANS BY ONLY 3C (5F)...

PERSON SWIMMING IN THE OCEAN.

... **LAND AREAS** BY AN AVERAGE OF 5C (9F)...

SAME PERSON GETTING OUT OF THE OCEAN WALKING ON THE BEACH, SAYING:

OUCH OUCH OUCH OUCH.

... AND THE **ARCTIC** BY A WHOPPING 8C (15F).

**LESS ICE MEANS LESS REFLECTION** OF SOLAR ENERGY.

IT'S THE **ALBEDO EFFECT!**

ALBEDO GUY REAPPEARS HERE

AND THAT'S JUST THE **TIP OF THE ICEBERG.**

## Welcome to the Arctic Circle

an emerging epicenter of industry and trade akin to the Mediterranean Sea.

IMHO WE CAN CUT THIS, HERE, WE'LL MAKE SURE TO BALANCE GOOD AND BAD ELSEWHERE. THE POINT IS THERE ARE BIG CHANGES ALL OVER THE PLACE, AND BESIDES, NO MORE ICEBERGS ISN'T NECESSARILY INTRINSICALLY BAD

DRAWING OF THE TITANIC SAILING COMFORTABLY

BOAT SAYS "TITANIC 2"

Well, there **USED TO BE ICEBERGS** here.

THE FACT IS, A GLOBAL INCREASE OF 4C (7F) WOULD **TRANSFORM THE ENTIRE WORLD...**

Welcome to the **FERTILE FARMLAND** of **BANGLADESH.**

Well, there **USED TO BE FARMLAND** here.

SCIENTISTS KNOW...

I LIKE THE SPIRIT OF THIS ONE A LOT, BUT I WONDER IF IT NEEDS SOME WORDSMITHING.

... YOU GET MORE **FOREST FIRES** WHEN IT'S **HOT AND DRY.**

## The World's Deserts

WORLD MAP

HMMMM... LET'S TWEAK THIS OR THE FOREST FIRE ONE...

NOW EVEN **BIGGER AND DRIER!**

Swim the **GREAT BARRIER REEF.**

HURRY, THE OFFER ENDS SOON!

Goodbye **FROSTBITE.**

... hello **HEATSTROKE.**

Greetings from **MINNESOTA...**

... where winters **don't suck anymore!**

When it comes to **Latitude**, **50** is the **new 40.**

Monsoons...

... **JUST GOT Monsoonier.**

# SIBERIA

MAYBE: PRIME FARMLAND FOR SALE

THE NEW **AGRICULTURAL HEARTLAND.**

... **BECAUSE WHEN THE CLIMATE CHANGES, EVERYTHING CHANGES.**

Y NOTE:

JUST A NOTE HERE THAT THE NEXT PAGE (INTRO TO THE WATER CHAPTER) ALSO HAS BREATHING SPACE AND OPPORTUNITIES FOR INTERESTING PICTURES, SO WE MIGHT NEED TO THINK ABOUT THE 2 OF THEM TOGETHER. AND MAYBE WE CAN EVEN COMBINE THEM IN SOME FUN WAY, E.G., THE WAVE IS ON THE LHS WITH ONE SCIENTIST ON IT AND THE OTHER SCIENTISTS ARE ON THE BEACH ON THE RHS? MAYBE THERE'S A RAINSTORM IN THE BACKGROUND? (SEE NOTES FOR THE NEXT CHAPTER, WHICH COVERS WATER/ICE/VAPOR, ABOUT HOW IT WOULD BE GOOD TO INCLUDE ALL OF WATER'S FORMS, LIQUID/GAS/SOLID.)

HOW ABOUT A HUGE WAVE LOOMING TO THE LEFT, CRESTING AND READY TO FALL ON THE SCIENTISTS.

**MANY OF THOSE CHANGES  
HAVE TO DO WITH  
WATER...**

**... SO THAT'S  
OUR NEXT  
TOPIC.**

BAH! DON'T BE SO RISK AVERSE!

IT'LL BE SOMETHING FUN ABOUT WATER, OR THE LACK OF IT, OR SOMETHING.

# CHAPTER 8

## H<sub>2</sub>O

*PI: INTRODUCTION*

*PI: [MAYBE THE INTRO PAGES IN PART II CAN ALL PLAY WITH THE "FIVE CHINAS" CHARACTERS IN SOME WAY? MAYBE IN THIS ONE THEY'RE PLAYING NEAR A FIRE HYDRANT? AND THERE'S AN ICE CREAM OR SNOW ICE VENDOR NEARBY?]*

*OTHER IDEAS: WATER IS ONE OF THE SIMPLEST MOLECULES... BUT THE INTERACTIONS BETWEEN WATER AND CLIMATE ARE ANYTHING BUT SIMPLE, OR A KID ASKS "WHY DOES IT MATTER WHETHER OR NOT THERE'S WATER ON MARS?" SCIENTIST ANSWERS "BECAUSE WATER IS FUNDAMENTAL TO LIFE."*

*ALT SOMETHING LIKE:*

*FORGET ABOUT CAKE... I WANT A SNOWCONE.*

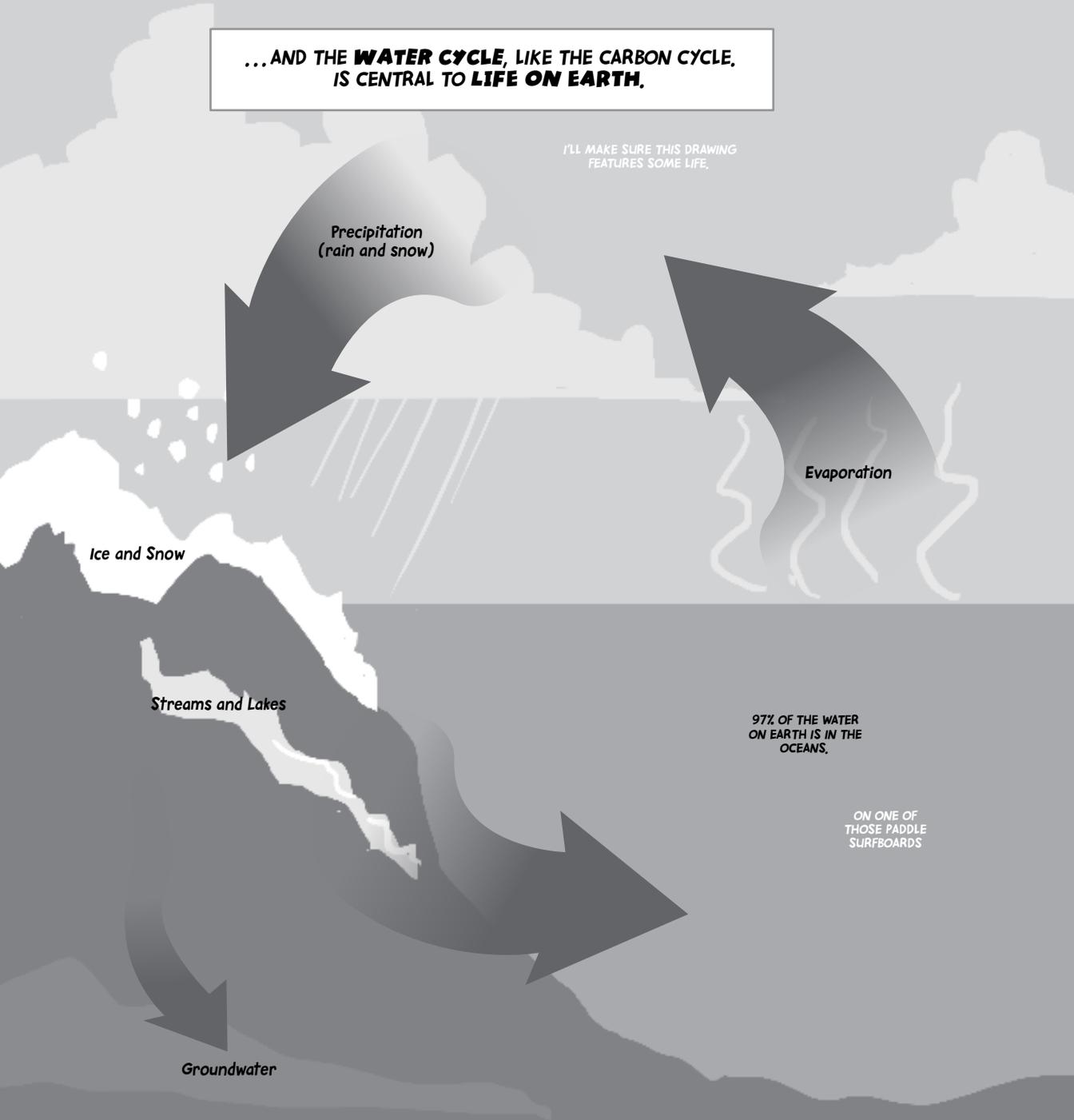
**WATER COVERS MOST OF THE EARTH'S SURFACE...**

WHY DO WE CALL  
IT "PLANET **EARTH**"  
WHEN IT'S  
**70% WATER?**

IN HOT AIR  
BALLOON, LOOKING  
DOWN WITH  
BINOCULARS.

...AND THE **WATER CYCLE**, LIKE THE CARBON CYCLE,  
IS CENTRAL TO **LIFE ON EARTH**.

I'LL MAKE SURE THIS DRAWING  
FEATURES SOME LIFE.

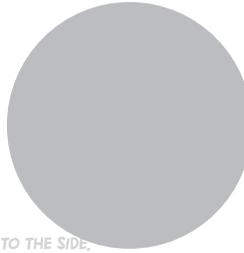


97% OF THE WATER  
ON EARTH IS IN THE  
OCEANS.

ON ONE OF  
THOSE PADDLE  
SURFBOARDS

**WATER AND CLIMATE ARE ALSO CLOSELY RELATED...**

**HUMID AIR AND OCEAN CURRENTS TRANSPORT ENERGY FROM THE EQUATOR TOWARD THE POLES,**



*I WAS HOPING TO AVOID MORE ARROWS ON THIS SPREAD, SO HOW ABOUT A GLOBE HERE, LIKE THE KIND ON A DESK, WITH AN AIR CONDITIONER STRAPPED TO THE TOP AND SOME FANS AROUND THE SIDES AND SUCH,*

*OR MAYBE ONE SCIENTIST RUNS A HAIR DRIER AND BLOWS UPWARD ON THE SIDE OF THE GLOBE, AND THERE'S A BIG ICE CUBE ON TOP OF THE GLOBE, MELTING,*

**LIKE A HEATING AND COOLING SYSTEM!**

*GLOBE WITH AN AIRCONDITIONER AND A FAN BOLTED TO THE SIDE,*

*OR MAYBE JUST LITTLE ARROWS SHOWING THE ATLANTIC OR PACIFIC CURRENTS AND THE SCIENTISTS HOLD THE FANS*

**... SO IT'S NOT SURPRISING THAT MANY OF THE MOST IMPORTANT IMPACTS OF CLIMATE CHANGE...**

**FLOODING!**

**MELTING!**

**SWEATING!**

**... ARE THOSE THAT AFFECT THE THREE FORMS OF WATER.**

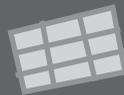
**LIQUID**



**WATER**

*CHARACTER POURS WATER FROM ONE CUP TO ANOTHER,*

**SOLID**



**ICE AND SNOW**

*CHARACTER HOLDS ICE CUBE TRAY*

**GAS**



**WATER VAPOR**

*CHARACTER LOOKS AT THE STEAM RISING ABOVE A TEAPOT*



**WE BEGIN WITH THE OCEANS, WHICH—LIKE THE REST OF THE PLANET—ARE WARMING UP.**

THE OCEANS CONTAIN  
97% OF THE WATER  
ON EARTH, ..

... AND ABSORB X% OF THE  
EXTRA HEAT FROM GLOBAL  
WARMING,

ON BOAT PUTTING THERMOMETER IN THE WATER,

**AS WATER HEATS UP, IT EXPANDS...**

JUST LIKE MERCURY IN  
A THERMOMETER,...

... OR HOT AIR  
IN A BALLOON,

**... AND THE RESULT IS RISING SEA LEVELS.**

**THERMAL EXPANSION**  
ACCOUNTS FOR ABOUT HALF OF  
SEA LEVEL RISE DURING THE  
20TH CENTURY,

THE OTHER HALF  
IS FROM MELTING  
GLACIERS AND ICE  
SHEETS,

MELING GLACIER HERE,  
MAYBE SOMEBODY RIDING AN ICEBERG? OR STANDING  
NEAR A GLACIER THAT'S CALVING INTO THE SEA? MAYE  
IT'S A SURFER WHOSE SURFBOARD IS STUCK IT THE  
GLACIER, BUT MAYBE NOT,

**UNDER BUSINESS AS USUAL, SEA LEVEL RISE IS LIKELY TO ACCELERATE IN THE YEARS AHEAD, POSING RISKS TO AGRICULTURE...**

INSTEAD OF WORRYING  
ABOUT **WEEDS**...

... I'M WORRIED ABOUT  
**SEAWEEDS.**

**... TO LOW-LYING CITIES...**

GAG HERE.

SOMETHING ABOUT NEW  
AMSTERDAM NEEDING MORE  
DYKES :-)

**... AND EVEN TO ENTIRE COUNTRIES.**

Welcome to the  
**MALDIVÉ ISLANDS.**

Well, there  
**USED TO BE  
ISLANDS**  
here.

**CURRENT ESTIMATES SUGGEST ABOUT 2 FEET OF SEA LEVEL RISE THIS CENTURY.**

CALL BACK TO THE  
FORTUNE TELLER.

**BUT IT COULD BE  
THREE TIMES  
MORE.**

TURN THE PAGE TO  
FIND OUT WHY!



**SEA LEVEL RISE THIS CENTURY DEPENDS MOSTLY ON THE ICE SHEETS OF GREENLAND AND ANTARCTICA.**

IF THEIR MASSIVE ICE SHEETS MELT **SLOWLY**, SEA LEVEL RISE WILL BE ABOUT **2 FEET**.

IF THEY MELT **QUICKLY**, IT'LL BE ABOUT **6 FEET**.

IN THESE TWO IMAGES WE CAN SHOW A TALL ICE SHEET OVER A RELATIVELY LOW SEA LEVEL, AND THEN IN A MELTED (I.E., LOWER) ICE SHEET OVER A RELATIVELY HIGH SEA LEVEL? (THIS CAN'T BE TO SCALE, UNFORTUNATELY, BECAUSE A FEW FEET OF SLR DOESN'T REALLY SHOW UP RELATIVE TO GIANT ICE SHEETS, BUT WILL STILL BE HELPFUL TO LOOK AT)

PENGUINS HERE,

**IN CONTRAST, MELTING ICE IN THE ARCTIC DOES NOT RAISE SEA LEVELS BECAUSE IT'S FLOATING...**

GLASS OF WATER BEFORE, WITH ICE CUBES IN IT...

WHEN FLOATING ICE MELTS...

... THE WATER LEVEL DOESN'T CHANGE.

BOTH THESE FRAMES FEATURE A WAITER HANDING A GLASS OF ICED TEA TO A CUSTOMER, WHO IN THE SECOND PANEL IS INCREDIBLY BORED.

GLASS OF WATER AFTER THE ICE HAS MELTED.

**... BUT IT DOES MEAN BIG CHANGES IN THE ARCTIC ENVIRONMENT.**

Welcome to the

# Arctic Circle

An emerging epicenter of industry and trade akin to the Mediterranean Sea.

The New **GREEN LAND.**

**MORE HEAT ALSO MEANS A SHIFT FROM SNOW TO RAIN...**

THESE WINTER OLYMPICS SURE ARE WEIRD!

MAYBE A SNOW MAKING MACHINE OVER HERE,

A WINTER OLYMPICS SCENE WITH A SKIER ABOUT TO START, BUT THERE'S ONLY PATCHES OF SNOW AMIDST THE PUDDLES, IT'S ALSO RAINING:

HILL HERE WITH EXPOSED ROCKS AND PUDDLES.

**... AND FASTER MELTING OF THE SNOW THAT DOES FALL,**

IN THIS PANEL THERE'S NO SNOW AT ALL, AND THE SKIER WALKS OFF THE PANEL SHOULDERING HER SKIS AND SAYS:

LET'S TRY **WATER SKIING** INSTEAD.

**OF COURSE SNOW ISN'T JUST FOR SKIING...**

IT'S ALSO A **NATURAL RESERVOIR** THAT STORES WATER FROM THE **RAINY SEASON...**

SNOW FALLS, FARMER LOOKS AT SNOWPACK AS IT BUILDS TO THE LEFT.

**... AND RELEASES IT IN THE SPRING AND SUMMER.**

FARMER WITH A HOSE COMING OUT OF THE SNOWPACK, WATERING PLANTS ON A SUNNY DAY.

CONSUMER HERE PICKING A TOMATO.

**... SO LACK OF SNOW COULD MEAN BIG TROUBLE FOR FARMERS, INDUSTRY AND CONSUMERS.**

ESPECIALLY WHEN COMBINED WITH **CHANGES IN RAINFALL...**

DRY FARMLAND HERE, HOSE GOES OFF TO THE LEFT, LEADS TO NOTHING.

**... WHICH IS OUR NEXT TOPIC.**

DEAD PLANTS HERE.

HOLDING HOSE UP TO TONGUE WITH ONLY A DROP DRIPPING OUT... A BUNCH OF PEOPLE HERE OFF TO THE RIGHT, STANDING IN LINE.



**WE LEARNED IN CHAPTER 5 THAT WATER VAPOR IS A GREENHOUSE GAS...**

**ENERGY IN?  
GO RIGHT  
AHEAD.**

ON THE SIDE OF THE CAR I'LL DRAW THE WAVELENGTHS, OR MAYBE IN THE TRACKS BEHIND THE CARS,

GOOD IDEA THAT,  
VISIBLE HERE, ..

**ENERGY OUT?  
STOP AND PUT  
YOUR HANDS UP!**

... INFRARED WAVELENGTHS HERE,

POLICE CHECKPOINT,

THIS CAR DRIVES RIGHT

THE COP IS MADE OF STEAM, IF I CAN PULL THAT OFF,

THIS CAR DRIVES LEFT, AND THERE ARE A FEW CARS IN LINE BEHIND IT,

**... AND IT TURNS OUT THE AMOUNT OF WATER VAPOR IN THE ATMOSPHERE DEPENDS ON THE TEMPERATURE.**

(CLAUSIUS, HOLDING HANDS WITH CLAPEYRON):

**THE CLAUSSIUS-CLAPEYRON RELATIONSHIP...**

(CLAPEYRON):

... SAYS THAT EVERY 1°C MEANS 7% MORE WATER VAPOR,

I'LL USE THE HILARIOUS PICTURES FROM HERE:  
[HTTP://EN, WIKIPEDIA, ORG/WIKI/RUDOLF CLAUSSIUS](http://en.wikipedia.org/wiki/Rudolf_Clausius)  
[HTTP://EN, WIKIPEDIA, ORG/WIKI/%C3%89MIL%C3%89\\_CLAPEYRON](http://en.wikipedia.org/wiki/%C3%89MIL%C3%89_Clapayron)

[THE HYPERLINK "HTTP://EN, WIKIPEDIA, ORG/WIKI/ATMOSPHERIC\_THERMODYNAMICS" \L "WATER\_VAPOR\_AND\_GLOBAL\_CLIMATE\_CHANGE" CLAUSSIUS-CLAPEYRON RELATIONSHIP SAYS THAT THE ATMOSPHERE CAN HOLD 7% MORE WATER FOR EACH ADDITIONAL DEGREE C...]

**GLOBAL WARMING THEREFORE MEANS MORE WATER VAPOR, WHICH IN TURN MEANS MORE GLOBAL WARMING.**

[HOW ABOUT A POSITIVE FEEDBACK DIAGRAM, WITH THE ARROWS THAT JUST CONTAIN TEXT: "WE LEARNED IN CHAPTER 4 / THAT WATER VAPOR / IS A GREENHOUSE GAS, ]

[PERHAPS A CHARACTER IN THE D SAYS SOMETHING GRUMPY HERE LIKE "DANG FEEDBACK LOOPS; THAT'S NOT REALLY FUNNY, BUT IT DOES SEEM LIKE THEY KEEP REAPPEARING AND MAYBE IT'S WORTH ACKNOWLEDGING SOMEHOW... MAYBE NOT, ]



PERHAPS IT'S CHASING SOMEONE

**GLOBAL WARMING ALSO MEANS  
BIG CHANGES IN PRECIPITATION.**

MORE DROUGHTS **AND**  
MORE FLOODS?

HOW DOES **THAT**  
WORK?

LEMME SHOW  
YOU,

**AS THE PLANET WARMS, THERE WILL BE  
MORE EVAPORATION FROM THE SURFACE...**

**... WHICH MEANS DRY PLACES WILL GET DRIER.**

DESERT.

SOMETHING  
ABOUT  
SUCKING THE  
MOISTURE  
OUT OF A  
ROCK,..

OR MENTION  
OF THE DRY  
PLACE IN  
CHILE.

**BUT EXTRA MOISTURE IN THE ATMOSPHERE MEANS  
MORE INTENSE RAINSTORMS...**

**... SO WET PLACES WILL GET WETTER.**

PERSON USING UMBRELLA AS A  
BOAT PERHAPS,

**THE WATER CYCLE IS  
GOING CRAZY!**



SOMEONE FLOATING OR PIRATE  
OR HOT AIR BALLOON

**CALLBACK!**

**FINALLY, WE RETURN  
TO THE OCEANS.**

THEY'RE NOT JUST  
**E\*PANDING** AND  
**WARMING UP...**

... THEY'RE ALSO GETTING  
**MORE ACIDIC.**

PIRATES ON SHIP HERE,

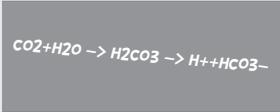
DUDE WALKING THE PLANKS  
SAYS,

**OCEAN ACIDIFICATION** HAPPENS WHEN  
**CO<sub>2</sub> FROM THE ATMOSPHERE DISSOLVES IN THE OCEANS...**

ARROW GRAPHIC BEHIND THE  
BOAT, THE EXHAUST MAKES  
UP SOME ARROWS, AND  
1/4 OF THE EXHAUST GOES  
DOWNWARD.

RECALL FROM CHAPTER 4  
THAT OVER 25% OF OUR  
CO<sub>2</sub> EMISSIONS END  
UP DOWN THERE,

RECALL THIS FROM  
**CHEMISTRY**  
CLASS!



**SHOW OFF!**



ALT, WHOLE SCENE IS  
UNDERWATER

SCIENTIST UNDER WATER IN  
DIVING COSTUMER,

CHALKBOARD

**... INCREASING THE CONCENTRATION OF HYDROGEN IONS IN THE WATER,**

MORE  
HYDROGEN  
IONS...

... MEANS **MORE**  
**ACIDIC.**

EVIL TWINS HOLD THE  
BLEACH AND THE COLA

Bleach  
(PH=12, 6)

Sea Water  
(PH=8)

Coca Cola  
(PH=2.52)

**INCREASED ACIDITY ERODES  
CORAL REEFS...**

THE ACIDITY IS BREAKING DOWN  
THE CORAL **FASTER THAN**  
I CAN BUILD IT UP.

A SNORKELER UNDER  
WATER

**... AND EATS AWAY THE SHELLS OF TINY SEA CREATURES.**

LIKE **PTEROPODS...**

**... COCCOLITHOPHORES...**

<HTTPS://WWW.GOOGLE.COM/SEARCH?Q=PTEROPODS&  
CLIENT=FIREFOX-A&HS=SGN&RLS=ORG, MOZILLA:EN-US:  
OFFICIAL&TBM=ISCH&TBO=U&SOURCE=UNIV&SA=X&EI=  
ICVDUERQNEHB1WKRIJOCGCW&VED=OCEIQSAQ&BIW=1320  
&BIH=682>

**... FORAMINIFERA...**

**... AND BIVALVES.**

BEAUTIFUL CRITTERS,  
BUT THEIR NAMES  
ARE **HARDER TO**  
**SWALLOW THAN**  
**GOOEY-DUCKS,**  
**ALT.**

BEAUTIFUL CRITTERS, BUT  
THEIR NAMES ARE **HARDER**  
**TO SWALLOW THAN**  
**GEODUCKS.**

THOSE SEA CREATURES FORM THE BASE OF THE **MARINE FOOD CHAIN**.

TINY PLANKTON EATING EVEN TINIER PLANKTON AND BEING EATEN BY A TINY FISH WHO'S BEING EATEN BY A SLIGHTLY LARGER FISH.

FIRST HALF OF THE FOOD CHAIN (ILLUSTRATION GOES HERE, (GOOD IDEA!))

AS A RESULT, OCEAN ACIDIFICATION THREATENS JUST ABOUT **EVERYTHING**, AND **EVERYONE**, CONNECTED TO THE SEA.

SECOND HALF OF THE FOOD CHAIN (ILLUSTRATION GOES HERE,

UH-OH

WITHOUT US,...

UH-OH

A BUNCH OF LITTLE TINY CREATURES THAT TOGETHER MAKE THE SHAPE OF A BIG FISH, AND THEY SAY

UH-OH

AND THEN THERE ARE A FEW MEDIUM-SIZED FISH (WHICH COMBINED MAKE THE SHAPE OF A BIG FISH) CHASING THEM,

AND THEN THERE'S A BIG FISH CHASING THEM, SAYING "UH-OH,"

AND THEN THERE'S A FISHING BOAT OR PERSON ON A PIER (MAYBE WITH A PERSON DINING NEXT TO THEM) SAYING "UH-OH,"

NO WONDER **OCEAN ACIDIFICATION** IS SOMETIMES CALLED GLOBAL WARMING'S **EVIL TWIN**.

TWINS SAYING:

LET'S PUT THESE SNAILS IN COCA-COLA AND **WATCH THEIR SHELLS DISSOLVE**.

KITCHEN WITH WATER ICE AND BOILING KETTLE OVER HERE,

**WE'RE DOUBLE TROUBLE!**

# **CHAPTER 9**

## **LIFE ON EARTH**

*MAYBE THE 5 CHARACTERS ARE AT A NATURAL HISTORY MUSEUM  
WITH 4 DIORAMAS OR SO,*

*MAYBE ONE HAS A POLAR BEAR, ONE HAS A DINOSAUR, AND THERE  
ARE TWO WITH PEOPLE, ONE POOR, ONE RICH*

**WHEN CIRCUMSTANCES CHANGE,  
LIVING THINGS **ADAPT...****

BEHIND THE COUNTER THE BUTCHER SAYS:

**SORRY, NO SEAL MEAT TODAY.**

POLAR BEAR AT THE MEAT COUNTER AT  
A SUPERMARKET,

HAS POLAR BEAR KID IN SHOPPING  
CART

SIGN SHOWS SNOW GOOSE IS MARKET DOWN SPECIAL

**IN THAT CASE, GIVE ME  
50 POUNDS OF SNOW  
GOOSE,**

**...AND SPECIES **EVOLVE...****

THE MOTHER READING TO TWO CUBS, OR  
LOOKING AT FAMILY PHOTOS IN AN ALBUM:

**GO BACK 100,000  
GENERATIONS AND YOUR  
ANCESTORS JUST WERE REGULAR  
OLD **BROWN BEARS.****

READING ON A COUCH, ONE CUB  
ON EITHER SIDE OF THE MOTHER;  
MY GODMOTHER DID THIS WITH  
ME AND MY BROTHER AND SHE'D  
SAY "DING" WHEN SHE WANTED  
US TO TURN THE PAGE :) AH,  
MEMORIES...

**...AND IF THEY DON'T SUCCEED  
IT'S **CURTAINS.****

WHINGING  
YOUNGSTER

**WHAT USE ARE BIG WEBBED FEET AND  
TRANSPARENT FUR IF THERE'S  
**NO MORE ICE?****

STERN TALKING  
TO FROM MOTHER  
BEAR:

**THAT'S WHY YOU NEED TO  
GO TO SCHOOL AND  
PAY ATTENTION!**

**MANY OF THE CHANGING CIRCUMSTANCES IN THE WORLD TODAY ARE CAUSED BY HUMANS...**

"CHANGING CIRCUMSTANCES: THAT'S THE UNDERSTATEMENT OF THE YEAR!"

PERHAPS IT'S A TINY BUG WHOS BEING ATTACKED BY A 5 CHINAS CHARACTER WITH A CAN OF RAID.

**Habitat Loss**

LADDER TOP HERE WITH ONE OF 5 CHINAS CHARACTERS ON TOP PUTTING THE TOP BOX ON TOP OF THE PILE.

**Invasive Species**

**Pollution**

**.... AND CLIMATE CHANGE IS GOING TO ADD AN EXTRA CHALLENGE.**

**Population**

BOX BEING CARRIED ON STAGE TO BOTTOM OF LADDER WHICH HAS ANOTHER OF THE 5 CHINAS CHARACTERS PUTTING HABITAT LOSS ON TOP OF THE CAMEL.

**Overharvesting**

**Climate Change**

CAMEL KNEELING (OR GETTING BURIED IN MUD?)  
WITH BOXES PILED ON TOP OF THEM LABELED WITH HIPPO STUFF:

AND THEN SOMEBODY (IN THIS SCENE OR THE NEXT ONE) IS ADDING A "CLIMATE CHANGE" BOX TO THE PILE. AND MAYBE IN THE BACKGROUND OF THE SCENE WE CAN VISUALLY SHOW SOME OF THESE OTHER ISSUES, E. G., HABITAT GETTING PAVED OVER, POACHERS SHOOTING AN ANIMAL, ETC.

CAMEL SQUISHED DOWN HERE, LEGS SPLOYED OUT.

I SUSPECT THERE'S NOT ROOM FOR THIS, SINCE THE CAMEL IMAGE IS STRONG.

[MAYBE THIS D IS WHERE WE PUT SOME CONTENT ABOUT EVIDENCE TO DATE OF CLIMATE CHANGE FROM SPECIES & C? SOMETHING LIKE "BECAUSE OF CLIMATE CHANGE WE'VE ALREADY MOVED 50 MILES NORTH, BUT I DON'T KNOW IF WE CAN KEEP GOING."] OR MAYBE THERE'S A RIVER IN THE WAY OR SOMETHING.

**CLIMATE CHANGE IS LIKELY TO BE A BIG PROBLEM FOR SPECIES THAT EVOLVE SLOWLY...**

**WE TAKE EVERYTHING SLOWLY.**

THE TURTLE IS WOOWING HIS PARTNER BY PUTTING ON A BARRY WHITE ALBUM.

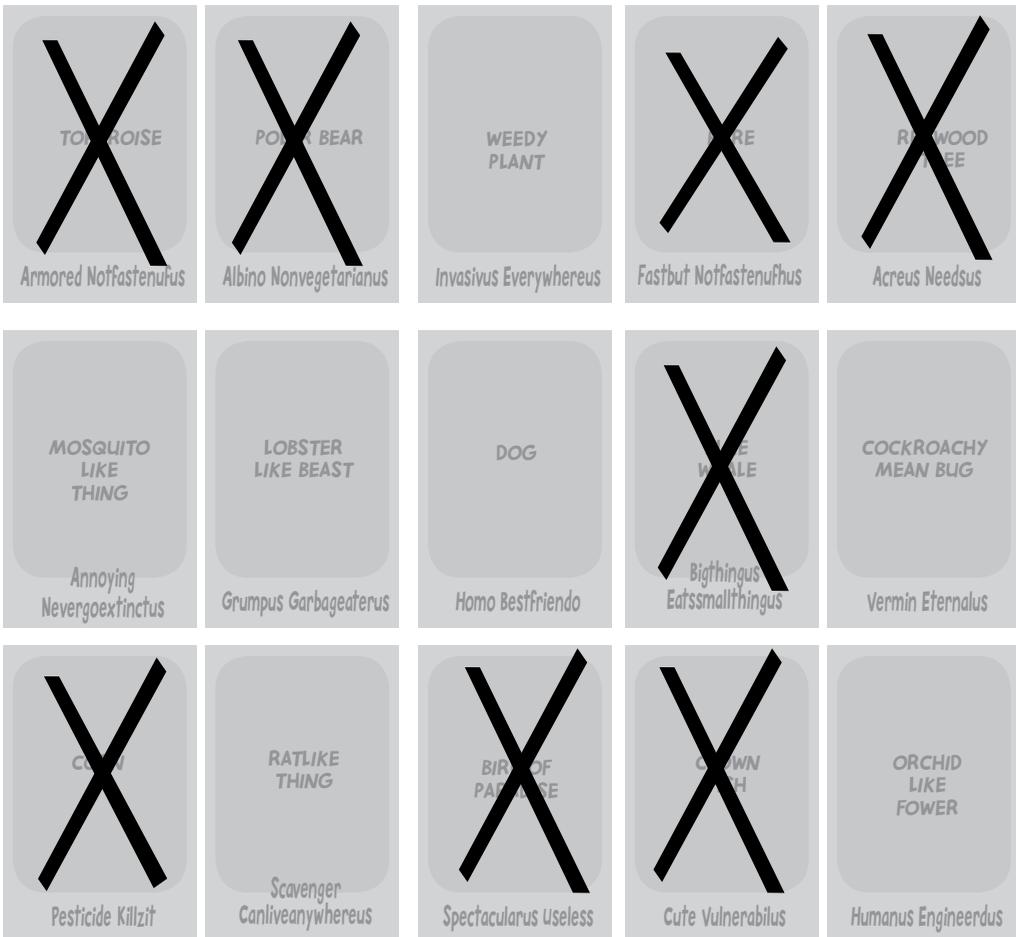
TWO TORTOISES HERE, WALKING ALONG.

**... AND SCIENTISTS ESTIMATE THAT 40-70% OF ALL THE SPECIES ON EARTH MAY GO ~~E~~TINCT OVER THE NEXT 100 YEARS.**

THESE PORTRAITS WILL ONLY HAVE SHAM LATIN NAMES, SOME OF THE PORTRAITS THEMSELVES WILL RESEMBLE CERTAIN SPECIES, BUT ONLY VAGUELY, AS WE'RE NOT MAKING REAL PREDICTIONS ABOUT ANY OF THEM.

THESE ARE OIL PAINTINGS AT THE NATURAL HISTORY MUSEUM!

PERHAPS THE X'S SHOULD BE BEING PAINTED BY A SCIENTIST ON A LADDER HOLDING A BUCKET OF PAINT AND A PAINTBRUSH



MAYBE ADD:

Rodentus Sexmaniacus  
ALT:

Thumper Humpfastimus

Omnivorous Stumphumper

Execrable Philofeucus  
"Shitbug"

Invidius Gourmand

PERHAPS:

Geurnillavine

PERHAPS ALL THE CRITTERS ARE WEARING CLOTHES, ANTHROPOMORPHIZED LIKE THE PEOPLE WILL LOOK... PERHAPS THESE ARE LIKE POKEMON CARDS, THAT LIST SOME DETAILS ABOUT THEIR HABITAT AND ADAPTABILITY AND POPULATION SIZE AND ETC... THAT PART OF THE GAG MIGHT CARRY OVER WELL TO THE HUMANS WHEN WE INTRODUCE THEM.

**A CHANGING WORLD MAY BE LESS  
OF A PROBLEM FOR SPECIES THAT  
EVOLVE QUICKLY...**

**WE BREED LIKE  
RABBITS!**

HERE'S LOTS AND LOTS OF RABBITS AND RATS AND COCKROACHES AND WEEDS, RUNNING AHEAD OF  
THE TORTOISES,

RABBIT HERE LOOKING  
BACKWARDS,

RATS AND WEEDS AND INSECTS (COCKROACHES) HERE ARE MOVING AS FAST AS THE HARE  
PERHAPS, JUST A RACE SCENE,

[SPECIES NOT COVERED WITH AN X ON THE LHS]

**... OR CAN ADAPT QUICKLY...**

**THESE ARE REAL SPECIES:**

PIGEON

*Columba livia*

RAT

*Rattus norvegicus*

KUDZU

*Pueraria lobata*

AND THIS IS A MIRROR OR A PICTURE OF THE  
PERSON LOOKING AT IT,

BACK OF KIDS HEAD,  
HE HAS POINTY EARS,  
AS HE LOOKS INTO A  
MIRROR HE SAYS:

**HEY!**

**... OR MIGHT **BENEFIT** FROM THE NEW REALITY.**

CERTAIN PLANTS  
DO **BETTER** WITH  
MORE CO<sub>2</sub>...

**... AS LONG AS  
IT DOESN'T GET  
TOO HOT.**

ALT: AS LONG  
AS THEY DON'T  
GET TOO HOT,

THRIVING PLANT

AS FOR HOW CLIMATE CHANGE  
WILL AFFECT **HUMANS...**

## HALL OF MAN

FINALLY, SOMETHING  
I CAN **CARE**  
**ABOUT.**

C'MON DAD, LET'S  
GO BACK TO THE  
**ANIMALS!**

DAD

ALTS :

Lordovallshesurveysus

Homo Bigbrainiosus

Toosmartforherowngoodus

KID

... IT'S A BIT **HARD TO SAY** BECAUSE  
WE'RE SO GOOD AT **ADAPTING.**

WHAT IF **OCEAN**  
**ACIDIFICATION** DESTROYS  
MARINE ECOSYSTEMS?

THERE'S ALWAYS  
**FARMED FISH.**

AH, BUT WHAT  
WOULD YOU **FEED**  
THE FARMED FISH?

**CORN!**

AH, BUT HOW ARE  
YOU GOING TO  
**GROW ALL THAT**  
**CORN?**

**GENETIC**  
**MODIFICATION!**

AH, BUT THEN THE  
FISH WILL TASTE LESS  
LIKE FISH AND MORE  
LIKE **CORN.**

**MY TASTE**  
**BUDS WILL**  
**ADAPT.**

OF COURSE **ADAPTATION** WON'T NECESSARILY BE EASY.

THIS IS A  
THREAT TO MY  
**QUALITY OF  
LIFE.**

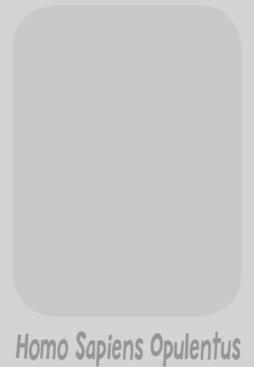
THIS IS A THREAT  
TO MY **ACTUAL  
LIFE.**

**BUT IT WILL DEFINITELY BE EASIER FOR THE WEALTHY...**

[AIR CONDITIONING, MOVE, ETC.] PERHAPS VISUALLY INDICATE RICH PERSON HERE.

HERE I IMAGINE FEATURING THE TRADING CARD TO THE RIGHT AND JUST A PICTURE OF A RICH FAMILY WITH ALL THEIR STUFF... LOTS AND LOTS OF STUFF.

HERE I COULD ADD SOME STATUES MAYBE.



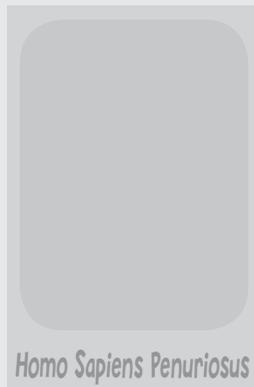
Homo Sapiens Opulentus

**... THAN FOR THE POOR.**

HERE I IMAGINE FEATURING THE TRADING CARD TO THE RIGHT AND JUST A PICTURE OF A POOR FAMILY AND THEIR LACK OF STUFF... NO STUFF AT ALL WHEN COMPARED WITH THE ABOVE..

[MOST HISTORIC EMISSIONS HAVE BEEN CAUSED BY RICH PEOPLE AND THE RICH WORLD, GET FACTS HERE,] AND VISUALLY INDICATE POOR PERSON HERE.

HERE MAYBE THE PEOPLE HAVE THE SAME OUTFITS AND PROPS AS THE FAMILY OF ANIMALS ON PAGE 2.



Homo Sapiens Penuriosus

**YOU CAN SEE THE GAP BETWEEN RICH AND POOR  
WHEN YOU LOOK AT SEA LEVEL RISE...**

OH, NO!  
MY **SUMMER**  
**HOME!**

OH, NO!  
MY **FARM!**

**... HEAT WAVES...**

ON THE PLUS SIDE,  
WE'VE GOT **A/C** AND  
**ICED MARGARITAS!**

ON THE PLUS SIDE,  
IN THE **WINTER**  
IT WON'T BE SO  
**COLD.**

BUT WE CAN JUST SAY *INSIDE* OR *MOVE NORTH!*

*SWEATING POOR PERSON*

**... EXTREME WEATHER...**

FLOODS?

DUST  
STORMS?

THIS 4x4  
HANDLES IT ALL.

OUR TIN ROOF  
DOUBLES AS A  
FLOTATION DEVICE.

**... HIGHER FOOD PRICES...**

**\$6 FOR A  
FRAPPUCCINO?**

**GUESS I WON'T BUY  
ANOTHER UNTIL  
TOMORROW.**

**\$6 FOR A  
BAG OF  
RICE?**

**GUESS I WON'T  
BUY ANOTHER  
UNTIL NEXT  
MONTH.**

**... AND DISEASE OUTBREAKS.**

**BOTH THESE ARE SILENT PANELS, THE FIRST  
SHOWS A RICH WORLD KID AT THE DOCTORS  
OFFICE, MAYBE GETTING A SHOT, MAYBE JUST  
BEING TREATED...**

**... AND THIS SIDE JUST SHOWS A GRAVEYARD**

**FORTUNATELY, BY THE END OF THIS CENTURY WE'RE LIKELY TO SEE  
MORE RICH PEOPLE AND FEWER POOR PEOPLE.**

**REMEMBER THE  
HAPPY STORY  
WE TOLD IN  
CHAPTER 1?**

**POOR PERSON SAYS THIS:**

**YEAH, TELL IT TO ME  
AGAIN!**

WITHOUT A DOUBT, THOSE WHO ARE **LEFT BEHIND** BY ECONOMIC GROWTH WILL SUFFER THE MOST.

D (CLIMATE REFUGEE):

THAT'S ESPECIALLY UNFAIR SINCE WE HAVEN'T CONTRIBUTED MUCH TO THE PROBLEM.

PERHAPS HERE THERE'S A REFUGEE CAMP, AND IN THE FINAL PANEL THE RICH FAMILY ARE BEING INVITED IN.

BUT EVEN THOSE WHO **BENEFIT** FROM ECONOMIC GROWTH WILL FACE **BIG CHALLENGES...**

WHADDYA MEAN  
I CAN'T EAT  
MONEY?

I MISS ALL THAT  
BIODIVERSITY.

I MISS BEACHES.

FAMILY AT THE MUSEUM

GIRL CHILD

MOM

... AND THERE'S A CHANCE THAT EVEN THE RICH WILL BE **OVERWHELMED.**

MAYBE THEY'RE IN A GATED COMMUNITY, AND PEOPLE ARE TRYING TO CLIMB OVER OR BREAK DOWN THE GATES OR LAUNCH CATAPULTS. (MAYBE THEY'RE IN A MEDIEVAL CASTLE?) AND THE ATTACKERS ARE LABELED (ON THEIR CLOTHES OR ON THEIR WEAPONS OR ??) WITH "CLIMATE REFUGEES", "STORMS", "FOOD SUPPLY", ETC.

CLIMATE REFUGEES, STORMS, FOOD SUPPLY, MAYBE SOMEONE SAYS THIS TRANSITION TO CHIO:

ESPECIALLY TOWARDS THE END OF THE CENTURY.

SCIENTIST

# **CHAPTER 10**

## **BEYOND 2100**

**CHARACTER #1:**

**THE WORLD WILL CONTINUE BEYOND 2100, YOU KNOW.**

**CHARACTER #2:**

**AT LEAST WE HOPE SO!**

**[MAYBE IN THIS IMAGE THEY'RE TRYING TO LOOK OVER THE HORIZON? AND IN THE NEXT CHAPTER (ON UNCERTAINTY) THEY'RE TRYING TO LOOK THROUGH A FOG?]**

**LOOKING FARTHER OVER THE HORIZON**

**WE'VE BEEN FOCUSING ON THE IMPACTS OF  
CLIMATE CHANGE IN THIS CENTURY.**



THIS 4c IS INTEGRATED INTO A ROAD SIGNS THIS TIME,  
AND A CAR WITH THE FAMILY IS WAITING IN FRONT OF  
IT, STOPPED, AS IF LOOKING AT IT.

**IN OTHER WORDS, WE'VE BEEN FOCUSING ON  
HOW CLIMATE CHANGE WILL AFFECT US...**

THESE FRAMES FEATURE DIFFERENT SPECIES AND THEIR DECENDANTS.

THEY AROUND THE PEOPLE, WHO AGE AND CHANGE STYLES AND HAVE KIDS... BUT THEN THEIR DOG HAS PUPPIES,  
AND A FAMILY OF RATS LIVING IN THE WALL, AND PIGEONS ON THE WINDOW SILL ALSO REPRODUCE AND AGE.

**... AND OUR CHILDREN AND GRANDCHILDREN.**

**AND MAYBE OUR CHILDREN  
AND GRANDCHILDREN.**

8 YEAR OLD GIRL SAYS THIS TO BLUSHING 8 YEAR OLD BOY,  
OR MAYBE THE BOY IS RUNNING AWAY, OR STICKING OUT HIS  
TONGUE AND SAYING "YUK!"

**BUT EVEN IF WE WENT ~~COLD TURKEY~~ AND STOPPED EMITTING GREENHOUSE GASES ~~TODAY~~...**

**STOP!**

PARTY'S OVER.

CALL BACK TO ALIENS SHUTTING DOWN THE PARTY IN CHAPTER 7.

SAYING STOP, PARTY'S OVER...

IT'S A PARTY TRAIN, LIKE A PARTY BUS.

**... HUMAN-INDUCED CLIMATE CHANGE WOULD CONTINUE BEYOND 2100.**

ALIEN TRYING TO STOP THE TRAIN,  
BUT EVEN THOUGH HIS FEET ARE  
FIRMLY PLANTED, HE GETS PUSHED  
BACK LIKE MR INCREDIBLE OR  
SUPER MAN.

**I SAID "STOP",  
BY ZORG!**

**IN FACT, TEMPERATURES AND SEA  
LEVELS WOULD CONTINUE TO RISE FOR  
HUNDREDS OF YEARS.**

BAU IS A RACE CAR

AND "COLD TURKEY" IS A  
TURKEY...

THOUGH MAYBE IT NEEDS TO BE  
A CRAPPY OLDER RACE CAR AND  
THERE'S A TURKEY IN A HELMET  
DRIVING IT.



THEY'D JUST RISE  
**MORE SLOWLY**  
THAN IF WE KEEP  
POLLUTING.

PERHAPS THIS SCIENTIST IS SEATED  
ATOP THE BAU CAR, POINTING  
BACKWARDS TOWARD THE TURKEY,  
WHICH HAS JUST GONE PAST  
THE 4C

THE CAR FROM FRAME ONE IS STILL  
STOPPED BEFORE THE SIGN, BUT  
NOW THE TURKEY MOBILE AND THE  
BAU RACE CAR SPEED PAST IT AND  
WHIP PAST THE 4C SIGN.

ONE REASON FOR THESE VERY LONG-TERM IMPACTS IS THAT CO<sub>2</sub> IS A **LONG-LIVED GAS**.

LONG LIVE CO<sub>2</sub>!

WELL, THAT'S NOT REALLY WHAT WE MEANT.

ABOUT **HALF** OF THE CO<sub>2</sub> WE'RE EMITTING NOW WILL **STILL BE WARMING THE PLANET IN 100 YEARS...**

SILENT PANEL, WITH OLD MAN LOOKING UPWARD...

... AND ABOUT **HALF OF THAT AMOUNT** WILL **STILL BE AT IT IN A THOUSAND YEARS.**

AS FAR AS HUMANS ARE CONCERNED, THAT'S PRETTY MUCH **FOREVER.**

LIKE **TATTOOS.**

OR **NUCLEAR WASTE.**

**ANOTHER REASON IS THAT THE EARTH'S CLIMATE SYSTEM IS FAIRLY SLUGGISH.**

A SLUG WITH A WORLD INSTEAD OF A SHELL

**THIS MEANS THAT THE PLANET DOESN'T RESPOND INSTANTANEOUSLY TO CHANGES IN ENERGY BALANCE.**

PREPARING TO POKE

3 PANELS HERE:  
PANEL 1: SCIENTISTS STAND NEXT TO EACH OTHER, ONE HOLDS A STICK

PANEL 2:

FIRST SCIENTIST POKES SECOND SCIENTIST WITH A STICK  
PANEL 3:

THE OTHER SCIENTIST JUMPS OUT OF THE WAY, SAYING OUCH

POKE

OUCH!

I THINK THIS READS BEST IF THE PERSON HERE WALKS IN THE OTHER DIRECTION,

SO THE OBJECTIVE OF THE POKER IS TO TURN AROUND THE MOVING THING,

**INSTEAD IT RESPONDS GRADUALLY...**

PREPARING TO POKE

3 PANELS HERE:  
PANEL 1: SCIENTISTS STAND NEXT TO EACH OTHER, ONE HOLDS A STICK

POKE

PANEL 2:  
POKER LOOKS AT POKEE  
FIRST SCIENTIST POKES SECOND SCIENTIST WITH A STICK  
PANEL 3:

THE OTHER SCIENTIST JUMPS OUT OF THE WAY, SAYING OUCH

THIS D ALSO STARTS WITH THE TWO SCIENTISTS STANDING NEXT TO EACH OTHER, BUT THIS TIME THERE'S 2 OR 3 PANELS OF POKING BEFORE THE SCIENTIST SAYS OUCH,

POKER LOOKS AT POKEE

AND IN THIS FRAME, THE PERSON IS FINALLY TURNED AROUND,

OUCH!

**... AND GRADUALLY CAN MEAN HUNDREDS OR THOUSANDS OF YEARS.**

THIS D FEATURES ONE SCIENTIST AND THE SLUG, IN THE FIRST PANEL, IT'S JUST THE SCIENTIST AND THE SLUG NEXT TO EACH OTHER, THEN THERE'S ABOUT 20 LITTLE PANELS BEFORE THE SLUG NEVER SAYS OUCH, PANELS BLEED OFF THE PAGE,

I'M HAPPY TO LET THE FRAMES TELL THE TIME, FRAMES ARRANGED LIKE THIS IMPLY THE PASSAGE OF TIME, SO MORE FRAMES, MORE TIME,

**ONE ESPECIALLY  
SLUGGISH PART OF  
THE EARTH SYSTEM IS  
SEA LEVEL RISE.**

MAYBE A SCIENCE CLASS OR SOME SUCH SCENE  
WITH TWO "EXPERIMENTS" UP FRONT, ONE  
EXPERIMENT IS A GIANT POT OF WATER OVER A  
SMALL FLAME, AND THE OTHER IS A GIANT BLOCK  
OF ICE ON THE TABLE, AND MAYBE THE TWO  
EXPERIMENTS ARE LABELED:

AND ALL THE STUDENTS ARE  
SLEEPING

ZZZZZZ

Thermal  
Expansion

Melting Snow  
and Ice

**WE SAW IN CHAPTER 8 THAT SEAS ARE LIKELY TO RISE ABOUT 2 FEET BY 2100.**

**LOW TIDE  
IN 2100...**

WITH TOES JUST  
BARELY IN THE WATER,

... MIGHT BE HIGHER  
THAN **HIGH TIDE**  
WAS IN 2000.

WITH HEAD JUST  
BARELY ABOVE THE  
WATER,

STRETCHING DOWN  
WITH TOE

**BUT THERE'S A GOOD CHANCE SEAS WILL CONTINUE TO RISE FOR CENTURIES.**

ONCE GLACIERS **START**  
TO MELT IT'S HARD TO TELL  
WHEN THEY'LL **STOP.**

CLIMBING INTO BOAT  
PERHAPS,

IN DEEP WATER SUIT WITH  
BUBBLES RISING,

FISH AND CRABS

MELT ALL OF **GREENLAND** AND THE SEAS WOULD  
RISE BY ABOUT **20 FEET**.

GOODBYE **FLORIDA**,

MELT THE **WEST ANTARCTIC ICE SHEET** AND  
YOU'D GET **ANOTHER 20 FEET**.

GOODBYE **XYZ**,

BRAINSTORMS:

**MANHATTAN?**

**EAST  
VILLAGE?**

MELT **ALL** OF ANTARCTICA AND YOU'D GET  
**ANOTHER 200 FEET** OF SEA LEVEL RISE.

GOODBYE **GOLDEN  
GATE BRIDGE**,

OF COURSE, MELTING MILE-THICK ICE SHEETS WOULD TAKE  
**MANY HUNDREDS OF YEARS**.

**BUT... WHO KNOWS WHAT THE WORLD WILL LOOK LIKE IN HUNDREDS OF YEARS?**

THE WORLD  
POPULATION COULD BE  
**2 BILLION...**

...OR **36 BILLION.**

WE COULD DISCOVER  
**TECHNOLOGICAL  
MIRACLES...**

...OR RETURN TO THE  
**STONE AGE.**

WE COULD HAVE  
**UNDERWATER  
CITIES...**

...OR WIND UP  
**SWIMMING WITH  
THE FISHES.**

BOY

KIDS AND SCIENTIST IN ROWBOAT.

GIRL LOOKING DOWN INTO THE WATER.

**TO SEE HOW HARD IT IS TO LOOK BEYOND 2100,  
IMAGINE SOMEONE IN 1900...**

MAYBE A TIME MACHINE GOES  
BACK TO 1900 AND FINDS A  
FARMER?

**HOWDY  
STRANGER,**

OR PERHAPS THIS IS PEOPLE LOUNGING ON AN OLD  
FASHIONED BOAT, OR IN THE SAME POSITION AS THE  
GUYS ON THE LHS

**... TRYING TO ANTICIPATE TODAY'S WORLD.**

ANTIBIOTICS?

COMPUTERS?

SATELLITE-GUIDED  
TRACTORS?

WHAT KIND OF  
**NONSENSE** ARE YOU  
TALKING?

IN FACT, WHEN THE SWEDISH CHEMIST **ARRHENIUS** FIRST STUDIED CLIMATE CHANGE 100 YEARS AGO...

... HE THOUGHT THE RESULTS WOULD BE **GOOD**.

HE'S  
PUTTERING  
AROUND IN THE  
GARDEN OR IN  
A FIELD:

THE INCREASING  
PERCENTAGE OF CARBONIC  
ACID [CO<sub>2</sub>] IN THE  
ATMOSPHERE...

... WILL BRING  
FORTH MUCH MORE  
**ABUNDANT CROPS**  
THAN AT PRESENT.

OF COURSE, HE LIVED  
IN **SWEDEN**.

THIS JUST SHOWS HOW **TOUGH** IT IS TO MAKE **PREDICTIONS**...

... ESPECIALLY ABOUT THE **FUTURE**.

IN 100 YEARS WE'LL ALL BE  
**BETTER OFF** BECAUSE OF  
**ECONOMIC GROWTH**...

... UNLESS WE'RE  
**WORSE OFF** BECAUSE  
OF **ENVIRONMENTAL  
DEGRADATION**.

SAME KIDS FROM FIRST PANEL OF THIS SPREAD.

THE BOY ON THE ROWBOAT  
SAYS THIS STUFF.

IN SUM, ALTHOUGH THE **GENERAL TRAJECTORY** FOR  
THE EARTH'S CLIMATE SEEMS CLEAR,...

SLUG  
SAYS: I'M JUST GETTING  
STARTED,

... THE **LONG TIME SPAN** ASSOCIATED WITH GLOBAL WARMING, ..

THE CHOICES **YOU MAKE**  
WILL HAVE CONSEQUENCES  
FOR YOUR **GREAT GREAT**  
**GREAT GRANDCHILDREN.**

THE LITTLE GIRL IS WIDE EYED  
EXCITED,...

THE LITTLE BOY IS DIVING OUT OF  
THE BOAT TO GET AWAY,

SCIENTIST TO KIDS IN  
ROWBOAT,

... IS ONE OF THE **TWO MAJOR ISSUES**  
THAT ADD **UNCERTAINTY** TO THE  
PROBLEM OF CLIMATE CHANGE,

WHAT'S THE **OTHER**  
MAJOR ISSUE?

**UNCERTAINTY.**

PERHAPS KID IN BOAT LOOKS  
DOWN INTO THE WATER AND  
ASKS THIS QUESTION,

SLUG HERE, COMPLETING  
THE IDEA,

# **CHAPTER 11**

## **UNCERTAINTY**

*SOMETHING HERE, [MAYBE THE INTRO PAGES IN PART II CAN ALL PLAY WITH THE "FIVE CHINAS" CHARACTERS IN SOME WAY? (EXCEPT HERE MAYBE THERE ARE 7 OF THEM BECAUSE OF POPULATION GROWTH,) MAYBE IN THIS IMAGE THEY'RE TRYING TO LOOK OVER THE HORIZON—AS IN THE LAST CHAPTER— BUT THIS TIME THROUGH A FOG?] [OR MAYBE FOLKS HERE ARE LOOKING AT A BELL CURVE WITH A FAT TAIL? OR MAYBE A BELL—CURVE—SHAPED DRAGON WITH A FAT TAIL?]*

IN THIS CHAPTER WE'RE GOING TO TAKE A  
BREAK FROM **LIKELY OUTCOMES...**

TODAY WAS THE  
USUAL BLAH, BLAH  
BLAH,

...AND THINK FOR A BIT ABOUT  
**UNLIKELY OUTCOMES.**

THE **CEO GOT  
FIRED** AND THE  
BUILDING ALMOST  
**BURNED DOWN**  
AND SOMEONE  
GOT THE **EBOLA  
VIRUS...**

CONGRATULATIONS,  
IT'S A **GIRL!**

CONGRATULATIONS,  
IT'S **SEX#TUPLETS!**

GUY ON PHONE IN FRONT OF  
CRUMPLED CAR

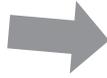
I JUST GOT  
IN A **FENDER  
BENDER...**

... WITH AN **ALIEN  
SPACECRAFT.**

WE'LL COME BACK TO HIM ON CAR  
INSURANCE PAGE

WHEN IT COMES TO CLIMATE, **UNLIKELY OUTCOMES**  
ARE, WELL, **UNLIKELY...**

**BAU**



**4°C**  
BY 2100

COULD  
TEMPERATURES  
INCREASE BY **6°C**?

OR BY  
ONLY **1°C**?

YES, BUT THAT  
WOULD BE  
**UNLIKELY.**

... BUT **UNLIKELY** DOESN'T MEAN **IMPOSSIBLE.**

**UNLIKELY:** THE  
ODDS ARE 1 IN 3.

**VERY UNLIKELY:**  
THE ODDS ARE 1 IN 10.

**E\*XTREMELY  
UNLIKELY:** THE  
ODDS ARE 1 IN 100.

**E\*TRA SUPER  
DUPER UNLIKELY:**  
LOOK, I WON THE LOTTERY!

WE CAN SEE THIS BY LOOKING AT THE **PAST PREDICTIONS** OF CLIMATE SCIENTISTS.

A CALL-BACK TO THE CRYSTAL  
BALL PLUGGED INTO A  
COMPUTER

**WHILE MANY SCIENTIFIC PREDICTIONS ABOUT CLIMATE CHANGE HAVE *HIT THE TARGET*...**

WE THOUGHT TEMP  
WOULD RISE THIS  
MUCH,..

... AND THEY DID,

WE THOUGHT SEAS WOULD RISE THIS MUCH,..

... AND THEY DID,

FILL IN THE DETAILS ABOVE  
AND ADD TWO MORE ONCE AR5  
COMES OUT,

**... OTHERS HAVE *MISSED*:**

**BOTH FOR *BETTER*...**

WE THOUGHT  
METHANE  
WOULD RISE THIS  
MUCH,..

... BUT IT ROSE  
**LESS,**

IN FRONT OF COWS HERE,

**... AND FOR *WORSE*.**

WE THOUGHT  
ARCTIC GLACIERS  
WOULD MELT,..

... BUT NOT **THIS  
FAST.**

IN OTHER WORDS, SOMETIMES  
SCENARIOS SCIENTISTS THOUGHT  
WERE **UNLIKELY**...

XYZ IS VERY  
UNLIKELY.

... **ACTUALLY CAME TO PASS.**

NEWS FLASH: XYZ  
JUST HAPPENED.

MADDENING THOUGH IT IS, THIS SORT OF  
**UNCERTAINTY** IS UNAVOIDABLE.

**ARRRRGH!**

LOTTERY  
WINNER:

TOUGH LUCK.



**ANOTHER CHALLENGE IS THE ~~COMPLEXITY~~ OF  
THE EARTH'S CLIMATE SYSTEM.**

JUST FINISHED STUFFING STUFF  
INTO THE COMPUTER, EMPTY  
BOXES EVERYWHERE,

BUT THERE'S A LARGE  
WRAPPED BOX ON THE  
FLOOR, AND IN FRAME  
2 SOMEBODY SAYS

I THINK WE'VE STUFFED  
EVERYTHING INSIDE,

HEY, WHAT'S THIS?

**ALL THIS COMPLEXITY MEANS THAT CLIMATE MODELS ARE *IMPERFECT*...**

SILENT PANEL

SCIENTISTS OVER HERE LOOKING APPREHENSIVE,  
PERHAPS ONE EVEN SWEARS, WITH HER HEAD IN  
HIS HANDS:  
\*#\$!

ONE OF THE SCIENTISTS SLOWLY PULLS THE RIBBON  
OFF THE LARGE PRESENT.

**... SO WE SHOULD BE *PREPARED FOR SURPRISES*.**

# **SURPRISE!**

MONSTER POPS OUT OF GIFT BOX:

DEALING WITH **UNCERTAINTY** IS A CHALLENGE...

THERE'S A 2% CHANCE  
YOU'LL **DIE** UNLESS  
WE DO **SURGERY**.

BUT IF WE DO SURGERY  
THERE'S A 4% CHANCE OF  
**COMPLICATIONS**.

... AND DEALING WITH CLIMATE CHANGE UNCERTAINTY IS A **HUGE CHALLENGE**.

MAYBE ANOTHER OPERATING ROOM SCENE, BUT THIS TIME THE PLANET IS  
ON THE TABLE? MAYBE A LINE ABOUT

WE BETTER NOT MESS THIS UP.

IF REALITY TURNS OUT TO BE **BETTER** THAN WE'D THOUGHT...

D: CARBON EMISSIONS AREN'T  
GROWING SO FAST, CLIMATE  
SENSITIVITY IS LOW, ETC.

... THEN BUSINESS AS USUAL **MIGHT NOT BE SO BAD**.

THEY'RE LEAVING  
THE HOSPITAL WITH  
A LINE ABOUT:

NOW YOU BE CAREFUL,  
YOU DODGED A BULLET  
BACK THERE.

ALT: EVERYBODY'S HAPPY AND THE DOCTOR WAVES AND SAYS

TAKE CARE NOW!

**BUT IF REALITY TURNS OUT TO BE *WORSE* THAN WE'D THOUGHT...**

*D: CARBON EMISSIONS ARE  
GROWING FASTER, CLIMATE  
SENSITIVITY IS HIGH, ETC.*

**... THEN BUSINESS AS USUAL COULD BE  
*CATASTROPHIC.***

*AND I THOUGHT IT WAS JUST  
**SCIENCE FICTION.***

*JUST A BIT PICTURE HERE PICTURE, WITH  
SEA LEVEL RISE AND A BIG DUST STORM AND  
EVERYTHING FALLING APART.*

ALL THIS TALK OF **POTENTIAL CATASTROPHES**  
SHOULD MAKE YOU THINK ABOUT **INSURANCE.**

CALL BACK TO THE GUY WHO'S CAR WAS  
FLATTENED BY AN ALIEN SPACECRAFT ON  
PAGE 2.

LIKE **CAR**  
**INSURANCE!**

AND GUY BEING PUSHED ALONG ON A  
STRETCHER

AND **HEALTH**  
**INSURANCE!**

IT'S **NOT LIKELY** THAT YOU'LL GET IN A  
**HORRIFIC CAR ACCIDENT...**

...OR BECOME **DEATHLY ILL...**

... BUT IT'S A SMART IDEA TO BUY **INSURANCE JUST IN CASE.**

YOU SHOULD AT LEAST  
HAVE **CATASTROPHIC**  
**COVERAGE.**

SIMILARLY, THE ODDS OF CLIMATE IMPACTS BEING **MUCH WORSE THAN ANTICIPATED** ARE NOT VERY HIGH...

IT'S **UNLIKELY**.

... BUT IT MIGHT BE A SMART IDEA FOR THE HUMAN RACE TO BUY **INSURANCE JUST IN CASE**.

YOU CAN BUY INSURANCE FOR **ALL KINDS OF THINGS**...

**LIFE**  
INSURANCE,

**DEATH**  
INSURANCE,

**FLOOD**  
INSURANCE,

**PET**  
INSURANCE,

**EVEN ALIEN**  
**ABDUCTION**  
INSURANCE,

... BUT HOW DO YOU BUY INSURANCE FOR THE **WHOLE PLANET**?

WELL, THE BEST WAY  
TO INSURE THE EARTH  
AGAINST CLIMATE  
CHANGE, .

...IS TO **REDUCE**  
**EMISSIONS** OF  
CO<sub>2</sub> AND OTHER  
GREENHOUSE  
GASES.

AND WE'LL BE  
TALKING ABOUT THAT  
MORE IN THE NEXT  
PART OF THE BOOK.