

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

BY **GRADY KLEIN** AND
YORAM BAUMAN, Ph.D.
THE WORLD'S FIRST AND ONLY **STAND-UP ECONOMIST**

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**PART
ONE**
OBSERVATIONS

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**...



... 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.

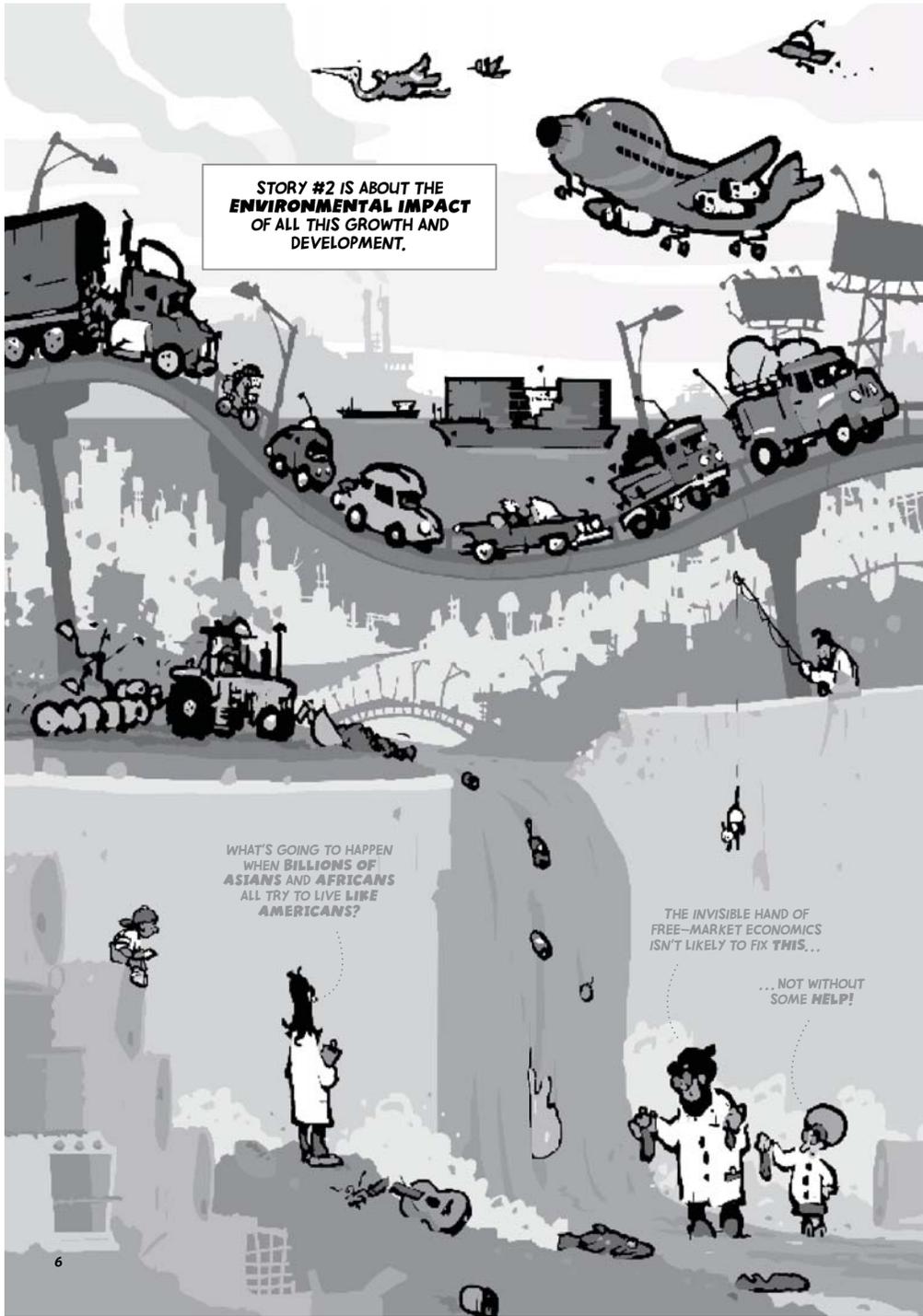


AS A RESULT, **STORY #1** POINTS IN A DIRECTION THAT'S NOTHING SHORT OF **MIRACULOUS**.



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?

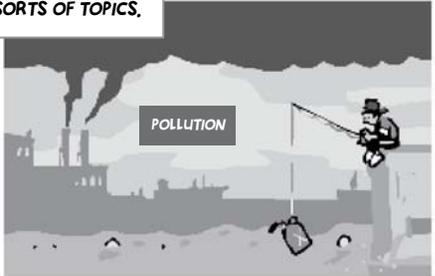
THE INVISIBLE HAND OF FREE-MARKET ECONOMICS ISN'T LIKELY TO FIX THIS...

... NOT WITHOUT SOME HELP!

ENVIRONMENTAL CONCERNS COVER ALL SORTS OF TOPICS.



OVERFISHING



POLLUTION

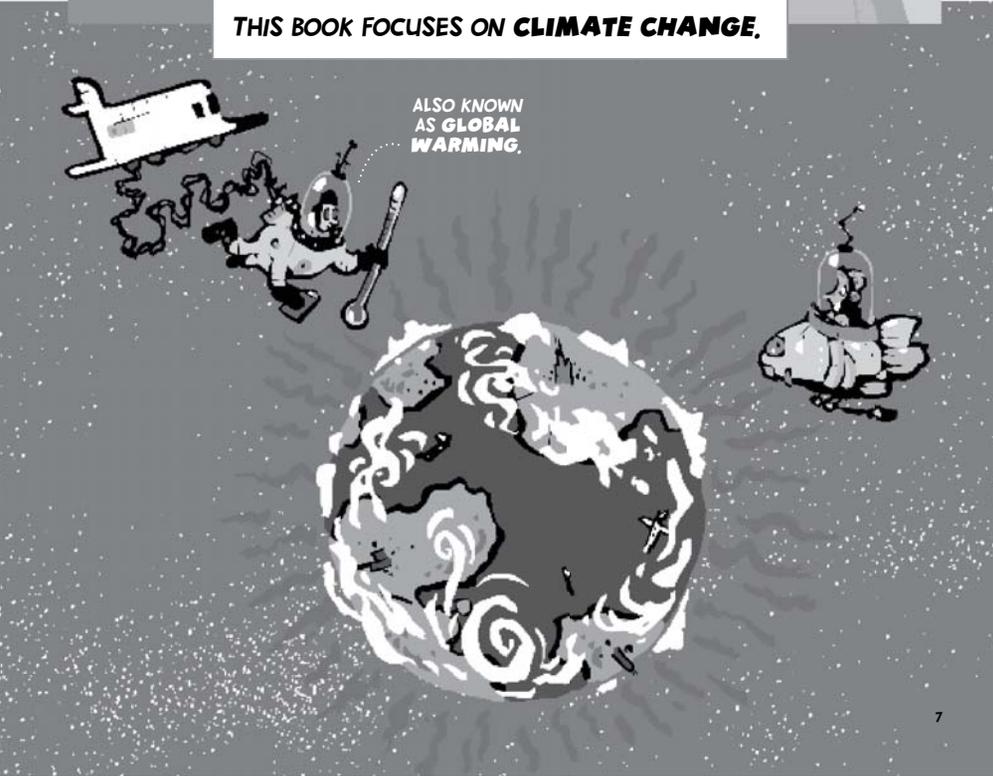


ENDANGERED SPECIES



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
ASTERIODS

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 21–28°C (69–82°F)...

... 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 ROY:

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

PERHAPS US, WITH MORE FIREFIGHTERS:

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

WELL, FIRST THE **EARTH COOLED,** AND THEN THE **DINOSAURS CAME...**



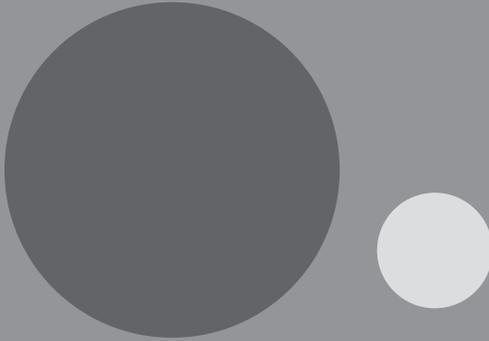
THE EARTH FORMED ABOUT
4.6 BILLION YEARS AGO.

THAT'S 50 MILLION
TIMES OLDER THAN
GRANDPA.

4.6 bya 4 bya 3 bya 2 bya 1 bya Now

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!

HARRIET

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!

HAROLD

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

EUREKA!

AMOEBAS LEAP OUT OF A
BATHTUB AND RUNS AROUND
OUTSIDE.

HUSBAND
SAYS:

EK! 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...

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

... INTO THINGS LIKE
BROCCOLI AND
BEAN SPROUTS.

OH **GREAT.**

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

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

EVERY YEAR ABOUT 120 BILLION TONS OF CARBON GETS SUCKED IN BY PLANTS THROUGH PHOTOSYNTHESIS...

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

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

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

SEE THE GLOSSARY FOR MORE DETAILS, LIKE OCEANIC PHOTOSYNTHESIS,

ALSO BY NICE TO HAVE A DYNAMIC FEEL HERE IN THE DRAWINGS, SO IT FEELS EXCITING,

FISH AND PLANTS AND FIRE AND BIRDS AND ETC,

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

SCIENTIST IN CAR OR ON BIKE

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

LEFT-TO-RIGHT LINE-UP OF A PLANT A COW A PERSON THE COW EATS THE PLANT, THE PERSON LOOKS AT THE COW HUNGRILY, WITH FORK AND KNIFE... THE FINAL LINE CAN BE SAID BY A SCIENTIST,

MOSTLY WATER AND CARBON,

MOSTLY WATER AND CARBON,

MOSTLY WATER AND CARBON,

YOU ARE WHAT YOU EAT!

HOW ABOUT IF THIS IS BROCCOLI FROM THE PREVIOUS PAGE, BUT DO COW'S EAT BROCCOLI?

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!

SCIENTIST HOLDING PLANT,

GETTING OXYGEN (O₂) INTO THE ATMOSPHERE WAS REALLY IMPORTANT BECAUSE...

KID
DUH! BECAUSE ANIMALS NEED OXYGEN TO BREATHE.

SCIENTIST #2

WELL, YES...

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

... BECAUSE IT LED TO THE CREATION OF A LAYER OF OZONE (O₃) IN THE UPPER ATMOSPHERE,

KID

WHAT'S SO IMPORTANT ABOUT THAT?

PERHAPS IN ASTRONAUT SUITS,

SCIENTIST #2

WELL, DUH,

SCIENTIST #3

LET ME TELL YOU...

DRAWING NOTE: THE OZONE LAYER SHOULD BE AT THE BOTTOM OF THE STRATOSPHERE, NOT AT THE TOP OF THE TROPOSPHERE,

OZONE LAYER

WHEN I DO THE DRAWING I'LL MAKE THE LAYERS LOOK LIKE THIS:

[HTTP://WWW.NC-CLIMATE.NCSU.EDU/EDU/K12/GEONSLAYER/BODY](http://www.nc-climate.ncsu.edu/edu/k12/geonslayer/body)

AND LINNY IT WITH THE PANEL ON PAGE 9

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

4.6 bya now

THE SUN GENERATES VISIBLE LIGHT...

AMBOBAS IN SCHOOL, UNDER WATER:

SCARY TEACHER SCARING THEM

... 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.

A BOTTLE OF SUNSCREEN HERE WITH A CLEVER NAME AND SOME TEXT LIKE:

PARTIAL PROTECTION AGAINST UVA AND UVB, COMPLETE PROTECTION AGAINST DEADLY UVC.

JUST PLAYING WITH IDEAS HERE, BUT MAYBE TWO BOTTLES:

SUNSCREEN: PROTECTS AGAINST UVA AND UVB FOR UP TO 2 HOURS.

OZONE: PROTECTS AGAINST DEADLY UVC FOR BILLIONS OF YEARS AND COUNTING.

[MAYBE SOMETHING ABOUT NOW WITH CATALYTIC ACTION!

TO ALLUDE TO THE NIFTY FACT THAT OZONE BLOCKS UVC WITHOUT ITSELF GETTING USED UP. INSTEAD WHAT HAPPENS (I THINK) IS THAT UVC KNOCKS O3 INTO O2+O, AND THEN THEY RECOMBINE AND CAN BLOCK MORE UVC.]

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

4.6 bya now

CALL BACK TO THE "EUREKA" MOMENT FROM P3:

HAROLD STREAKS ONTO LAND, WIFE SAYS:

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...

SCIENTIST TO GUY'S DRINKING SODAS AND CARRYING SIX PACKS OF SODAS.

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 (CFCS).

Y SAYS: SINCE WE HAVE AN IMAGE ON THE PREVIOUS SPREAD IDENTIFYING WHERE THE OZONE LAYER IS, MAYBE WE SHOULD REPLICATE THAT THERE AND THEN INDICATE WHERE MOST OF THE GHGS ARE (NAMELY IN THE TROPOSPHERE, THE LAYER CLOSEST TO THE EARTH). NOTE THAT THERE ARE SOME GHGS ABOVE THE TROPOSPHERE, BUT MOST RESIDE THERE.

I'LL STRIVE TO MAKE THIS GRAPHIC RESONATE WITH THE OZONE LAYER ON THE PREVIOUS SPREAD... TO INDICATE THAT THE GASES ACCUMULATE IN DIFFERENT LAYERS.

G REPLIES: GOOD IDEA! I'LL PLAN TO UNIFY THIS WITH THE GRAPHIC ON PAGE 7.

PERHAPS ON THE PLANET, A TINY TINY FACTORY EMITS THE CFC'S AND A TINY TINY CAR EMITS THE CO2

PERHAPS THE LINES ARE SAID BY SCIENTISTS IN ASTRONAUT COSTUMES.

GLOBAL WARMING IS RELATED TO HUMAN EMISSIONS OF GREENHOUSE GASES SUCH AS CARBON DIOXIDE (CO2).

NOTE THROUGHOUT NEED TO SUBSCRIPT THE 2 IN CO2.

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

[SCIENTIST #1:

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

SCIENTIST #2:

IF ONLY GLOBAL WARMING WERE SO EASY!

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

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

I THINK THIS LINE WORKS GREAT COMING OUT OF HARRIET'S LONG SUFFERING HUSBAND

THE ONLY THING PERMANENT IS CHANGE.

4.6 bya Now

THERE WERE TIMES WHEN ICE COVERED ALMOST EVERYTHING...

4.6 bya Now

THIS SNOWBALL EARTH IS FREEZING!

GOOD THING THERE WEREN'T ACTUALLY PEOPLE BACK THEN.

YORAM NEEDS TO WORK ON THIS TIMELINE.

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

4.6 bya Now

BOY, I COULD REALLY USE SOME ICED TEA!

SORRY, THERE'S NO ICE.

GOOD THING THERE WEREN'T ACTUALLY PEOPLE BACK THEN.

THREE PEOPLE FLOATING IN THE WATER (MAYBE NEAR A BOBBING SIGN SAYING "NORTH POLE", AND MAYBE THEY'RE ON COOL FLOATING THINGS LIKE AN INNER TUBE WITH THE HEAD OF A DUCK/DINOSAUR/ETC AND ONE OF THOSE FLOATING CHAISE LOUNGE THINGS WHERE YOU CAN STRETCH YOUR LEGS OUT AND THERE'S A PILLOW FOR YOUR HEAD). ANYWAY, THERE COULD BE TWO PEOPLE AND A SCIENTIST LOUNGING AROUND LIKE THIS

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!

SCARED LOOKING VELOCIRAPTOR CREEPED OUT BY THE BUGS.

GOOD THING THAT WAS BEFORE DINOSAURS.

(HERE'S LINKS TO COOL CARBONIFEROUS HYPERLINK "HTTP://WWW.BBC.CO.UK/NATURE/HISTORY OF THE EARTH/CARBONIFEROUS" TREES AND HYPERLINK "HTTP://WWW.BBC.CO.UK/NATURE/ANCIENT EARTH/COAL FOREST" SWAMPS AND HYPERLINK "HTTP://SCIENCE.NATIONALGEOGRAPHIC.COM/SCIENCE/PREHISTORIC-WORLD/CARBONIFEROUS/")

ANIMALS LIKE 6-FOOT CENTIPEDES, MAMMOTH COCKROACHES, 3-FOOT SCORPIONS, DRAGONFLIES THE SIZE OF SEAGULLS, AND 20-FOOT CROCODILES.)

(ALTERNATIVELY, THE SCIENTISTS COULD BE PADDING RIGHT-TO-LEFT ACROSS THE GRAPHIC, SAYING "ABOUT 300 MILLION YEARS AGO..." "SHORTLY BEFORE THE DINOSAURS!" AND THEN THERE'S THE JAWS OF A T-REX OR SOMETHING EMERGING FROM THE RHS OF THE PAGE (MAYBE RISING OUT OF THE SWAMP?). BUT... I'M A BIT WORRIED ABOUT HAVING HUMANS AND DINOSAURS IN THE SAME GRAPHIC. IT MIGHT BE OKAY AS LONG AS WE'RE CLEARLY BEING JOKEY ABOUT IT, BUT IT MIGHT BE A POINT OF CONTENTION WITH REVIEWERS. ALSO TECHNICALLY CARBONIFEROUS MEANS "COAL BEARING" BUT DINOSAURS DIDN'T APPEAR UNTIL ABOUT 230M YEARS AGO... BUT IT'S "SHORTLY BEFORE THE DINOSAURS!" ON GEOLOGIC TIME SCALES!])

[HERE'S SOME HYPERLINK "HTTP://EN.WIKIPEDIA.ORG/WIKI/CARBONIFEROUS" "LIFE" COOL IMAGES OF THE PERIOD.]

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

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

DOUG.

AMOEBAS HAVING A FUNERAL

AMOEBAS HAVING A FUNERAL

... 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...

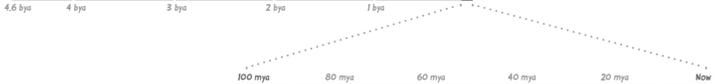
... AND PLENTY OF OIL AND NATURAL GAS TOO.

FILLING UP CAR,

JUST AN IDEA, BUT MAYBE A GAS STATION SIGN THAT HAS A GIANT COCKROACH OR SCORPION OR FERN OR SOMETHING, AND INSTEAD OF MOBIL IT'S CALLED CARBONIFEROUS?

(GOOGLE "SINCLAIR GAS" AND YOU'LL SEE THE DINO IMAGE, THAT'S KIND OF WHAT I'M THINKING...)

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,

JUST AN IDEA, BUT MAYBE THERE'S A COFFIN HERE AND THESE WORDS ARE COMING FROM SOMEONE HIDDEN INSIDE THE COFFIN, EXCEPT FOR ONE OR TWO CREEPY HANDS WITH LONG FINGERNAILS!

CORPSE WITH LONG FINGERNAILS?

ONE CONTENT HERE

ONE CONTENT HERE

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.

... OF WARM PERIODS...

... 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.

PERHAPS A LITTLE RODENT SAYS THIS LINE

THE IDEA IS TO HIGHLIGHT THE EVOLUTION FROM DINOSAURS INTO BIRDS.

SO THE CHICKEN AND THE DINOSAUR HAVE THE SAME GESTURE.

PERHAPS A PERSON SAYS THIS, SOMEHOW POSITIONED SO IS IN THE SAME PLACE AS THE RODENT.

SAME LANDSCAPE HERE AND BELOW, BUT THE ONE BELOW HAS HUGE GLACIERS INVADING.

PERHAPS BOTH PICTURES ALSO FEATURE AN ELEPHANT, HERE HE'S GOT NO HAIR, BELOW HE'S GOT A WARM COAT OF HAIR.

OR MAYBE THE COOL PERIOD HAS A MAMMOTH FROZEN INTO THE GLACIER?

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

... BUT CALM IS A RELATIVE TERM.

NO SNOWBALL EARTHS...

... AND NO TROPICAL NORTH POLES!

YORAM NEEDS TO DOUBLE-CHECK THIS FRAME.

LOOK, I'VE CALMED DOWN!

WOW, WHAT WERE YOU LIKE BEFORE?

SCIENTIST

KID GOING BONKERS

... AND COOL PERIODS.

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

EVERYONE ELSE CALLS THEM **ICE AGES**.

THIS PICTURE HAS A HUGE GLACIER AND WOOLY MAMMOTHS.

100 mya Now

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

BE NICE IF THE SCIENTIST WAS RIDING THE DINOSAUR AND THE DINOSAUR WAS LOOKING RIGHT HERE AT THE BLACK LINE, BUT I'M NOT SURE IT'LL BE POSSIBLE WITH THESE LINES.

TA DA!

DON'T FORGET THIS CHARACTER NEEDS RELATIVELY DARK SKIN.

DINOSAUR
MAMMOTH

HUMAN TIME SCALES ARE WAY DIFFERENT THAN GEOLOGIC TIME SCALES.

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

LADY GAGA OR SCIENTIST

CHARACTERS FROM PAGE 2.

GRANDPA GRUMPILY PULLING HIS GOLF BAG

RETURN TO KID AT BEGINNING.

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

I WONDER WHERE I CAN **CATCH SOME FISH?**

I WONDER HOW I CAN **AVOID BEING EATEN BY A TIGER?**

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

CHAPTER 3

THE ICE AGES

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

ON THE BEACH, SCIENTIST SAYS THIS TO SUNBATHER.

[MAYBE THE PERSON IS NEAR A BOULDER FIELD OR SOMETHING? IT WAS THE PRESENCE OF WEIRD BOULDERS FROM FAR AWAY THAT LED SCIENTISTS TO REALIZE THAT THERE WERE GIANT GLACIERS & ETC BACK IN THE DAY.

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!**

I'LL DRAW HER AS A CYCLOPS :-)

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



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

2 SCIENTISTS, ONE STANDS ON OTHERS SHOULDERS

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

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

PENGUINS...

falling
SNOW
GOT
COMPRESSED,
TRAPPING ANCIENT AIR
IN ANCIENT ICE.

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

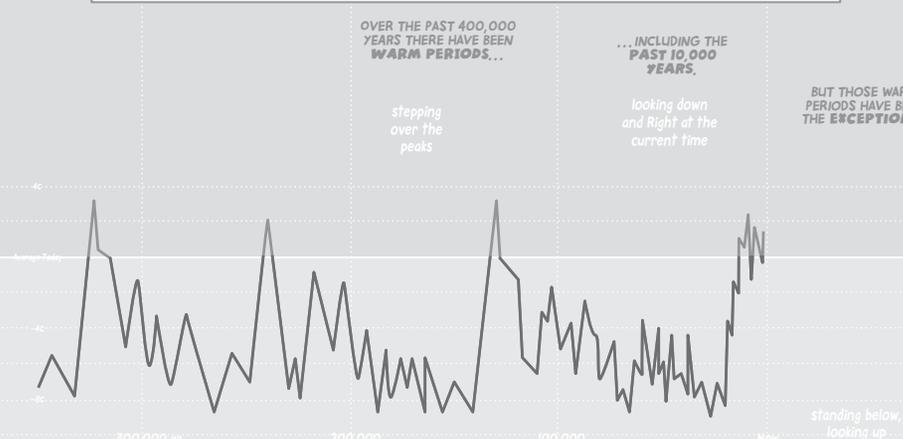
I'VE GOT A 6-FOOT **COD!**

I'VE GOT A MILE-LONG **ICE CORE!**

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

IT'S LIKE **COUNTING TREE RINGS**.

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



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 PUT **CHICAGO UNDER A MILE OF ICE**.

THE MYSTERY OF THE ICE AGES...

A RETURN TO
19TH CENTURY
GEOLOGISTS FROM
THE TOP OF THE LAST
SPREAD:

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.

PLAYING WITH TOP,
SHOWING THE KID THE TOP.

... 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.

NOT TO SCALE.

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

AND NOW, IN **ASTRONOMY**
NEWS, THE TILT OF THE EARTH
IS **23.4 DEGREES** AND SLOWLY
GETTING **WEAKER.**

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

OR THIS COULD
BE CROLL GIVING
TECHNICAL DETAILS.



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!

CHARACTER HERE,
TILTED OVER

ALT,
... AND INTO
THE FREEZER.

ALT,
OUT OF THE
FRYING
PAN...

... 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.

CHARACTER HERE,
TILTED OVER LESS,
THIS WILL BE A HAND
DRAWING.

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

THEY'RE THE
MILANKOVITCH
CYCLES.

MM TO KID,

PERHAPS HOOLA HOOPS FOR BOTH MM
AND KID

MM WIGGLING, NOT SAYING IT, BUT WIGGLING
HIS HIPS..

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

THEY'RE **WIGGLES** AND **JIGGLES!**

MM DANCES AROUND WIGGLING AND JIGGLING,

OR HOOLA HOOPING!

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

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

START ROCK BAND/ MARCHING BAND ANALOGY HERE,

I'M THE PACEMAKER,

MM IS THE DRUMMER FOR THE BAND

I'M GOING **INTERGLACIAL!**

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

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

PERHAPS SOME SETUP HERE THAT IT'S LIKE A BIRTHDAY PARTY,

KID DRINKS SODA

HAVE SOME **SODA.**

SHAZAM!

KID SCREAMS AND RUNS AROUND ->

OR HOOLA HOOPS LIKE CRAZY?

KID GOES CRAZY

I'M **THIRSTY.**

KID SAYS I'M THIRSTY

IN THIS PICTURE HE HAS A CAPE,

KID DRINKS SODA

LET'S **SNUGGLE.**

YAWN.

KID SNOOZES

IN THIS PICTURE HE HAS A BLANKIE

I'M **SLEEPY.**

KID SAYS I'M THIRSTY

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...

...OR READ MY
626-PAGE BOOK!

MILANKOVITCH:

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

LIKE THE ONE
THAT PEAKED
20,000 YEARS
AGO.

MAYBE INCLUDE A MAP OF WHAT THE EARTH LOOKED LIKE AT THE PEAK OF THE
LAST ICE AGE?

[HTTP://WWW.SCOTESE.COM/IMAGES/LGM.JPG](http://www.scotese.com/images/lgm.jpg)

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

HOT HOT
SUMMERS.

LOTS OF MELTING ICE
AND SNOW.

COLD COLD
WINTERS.

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

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

SOME GAG ABOUT BEING IN CANADA WITH LESS
SNOW.

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.

WITH FULL HEAD OF
HAIR!!!!

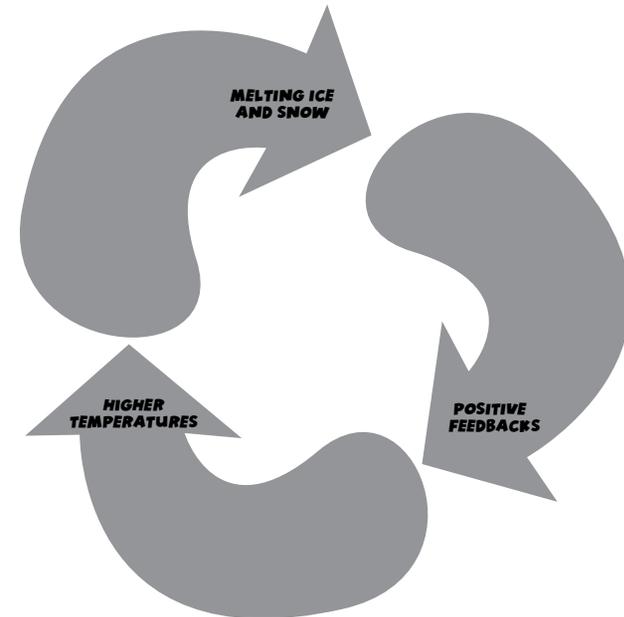
LAND AND WATER
ABSORB MORE
SUNLIGHT, WARMING
THE PLANET.

THIS IS A BALD GUY!!:
(I LOVE THIS!)

ROCK STAR HAIR!!!!

COULD BE DIFFERENT
MEMBERS OF THE
BAND... COULD BE ONE
OF OUR SCIENTISTS IS
BALD, ANOTHER HAS
BIG HAIR.

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



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

SHOW MM DRUMMER
LEADING THE BAND HERE.

THESE ARE FANS ATTENDING THE CONCERT, SO YOU SEE THE
BAND AND THE AMP'S ON-STAGE, AND THE CONVERSATION
HERE IS THE CLASSICAL CONVERSATION BETWEEN PEOPLE WHO
CAN'T HEAR EACH OTHER:

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

WHAT???

FINGERS IN EARS.

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**.

SCIENTISTS OUTSIDE THE MUSIC VENUE, BUYING TICKETS OR WAITING IN LINE OR
WHATEVER? WITH A MARQUEE SAYING:

TONIGHT:

MILANKOVITCH AND THE FEEDBACKS

WE COULD EVEN ADD SOME ADDITIONAL BAND NAMES TO THE MARQUEE, LIKE TWO OF
MY FAVORITES FROM AROUND SEATTLE:

EXTRA FINE SHREDDED LETTUCE
THE UNIBROZ

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

**MILD
SUMMERS.**

NOT MUCH MELTING ICE
AND SNOW.

**MILD
WINTERS.**

BUT STILL COLD
ENOUGH FOR SNOW
IN PLACES LIKE
CANADA.

SKIING?

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

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

ICE HOCKEY!

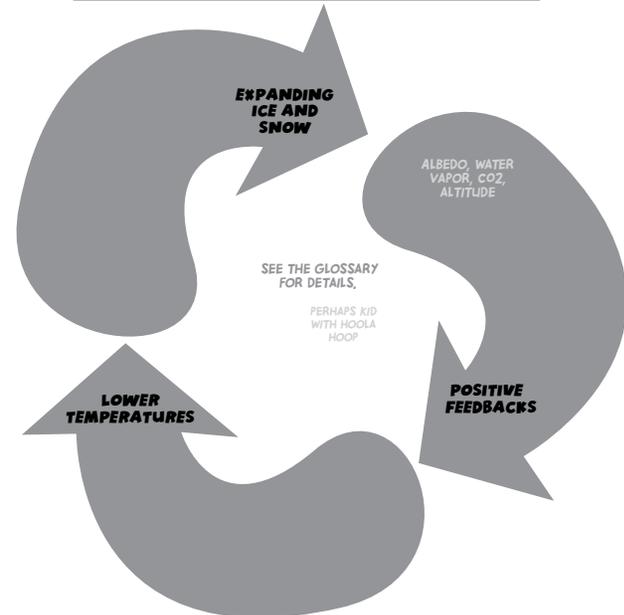
NOW THE **ALBEDO EFFECT** WORKS IN THE **OTHER DIRECTION...**

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**.



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?**

WHAT??

I'M NOT SURE WHAT THIS "WHAT" IS
DOING HERE?

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

OH NO, I BETTER
STOCK UP ON
HEATING OIL!

ROCK FAN AGAIN:

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

AH, **NEVER**
MIND!

OTHER ROCK FAN

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

UM, ABOUT THAT
HEATING OIL...

SCIENTIST FROM
BEHIND THE TWO OF
THEM,

ROCK FAN

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
GAS MOLECULES...

... INCLUDING ABOUT
2,100,000,000,000,000,000,000
MOLECULES OF O₂...

... AND ABOUT
4,000,000,000,000,000,000
MOLECULES OF CO₂.



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, N₂:

I'M INTO N₂
N₂ DEEP
N₂ THE DRAGON
N₂ 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 (CO₂).**

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."

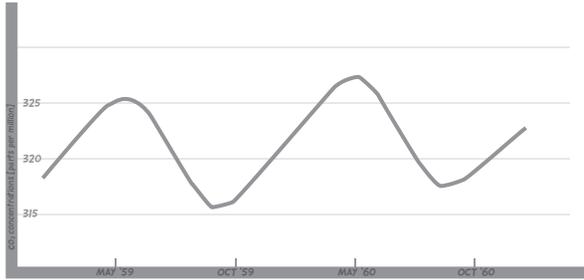
WEARING SNORKELING GEAR

...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.



D1 (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**...

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

LOOK AT
PAGE #!

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

LOOK AT
PAGE #!

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!



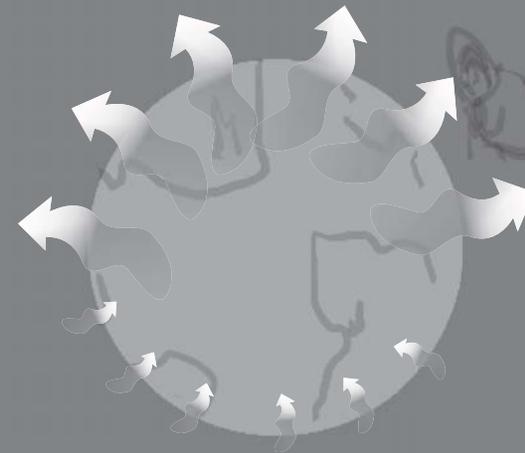
**MORE LAND MEANS
MORE GREEN
STUFF.**

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.

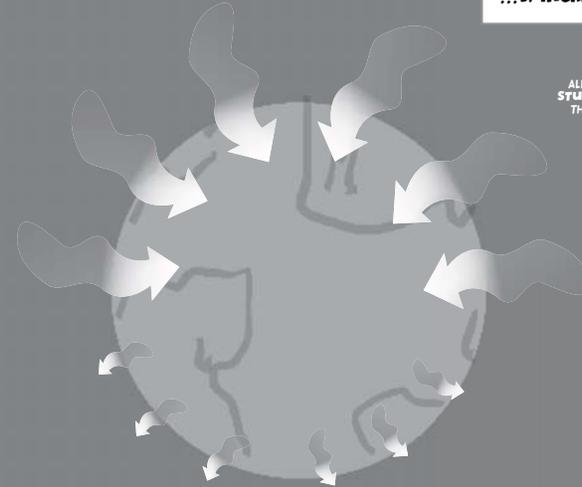


OF COURSE, WINTER
IN THE NORTH IS
SUMMER IN THE
SOUTH...

... 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...

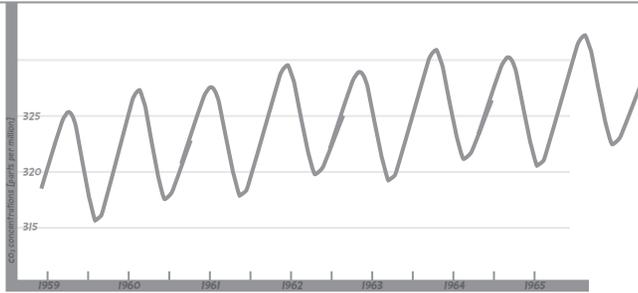
... BY **INCREASED PHOTOSYNTHESIS.**



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**...

HOLDING THIS UP,



...IN EVERY **3.67 TONS OF CO₂ MOLECULES**.

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!**

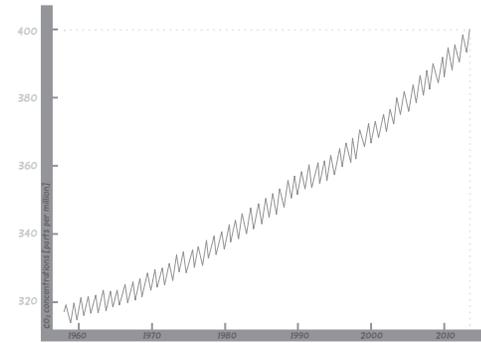
THIS TIME IT'S THE DAD IS GRANDPA AGE, THE SON IS DAD AGE, AND THE LINES ARE VIRTUALLY THE SAME:

WITH SNORKLE AND FINS.

SORRY, DAD, NOT NOW.

[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...

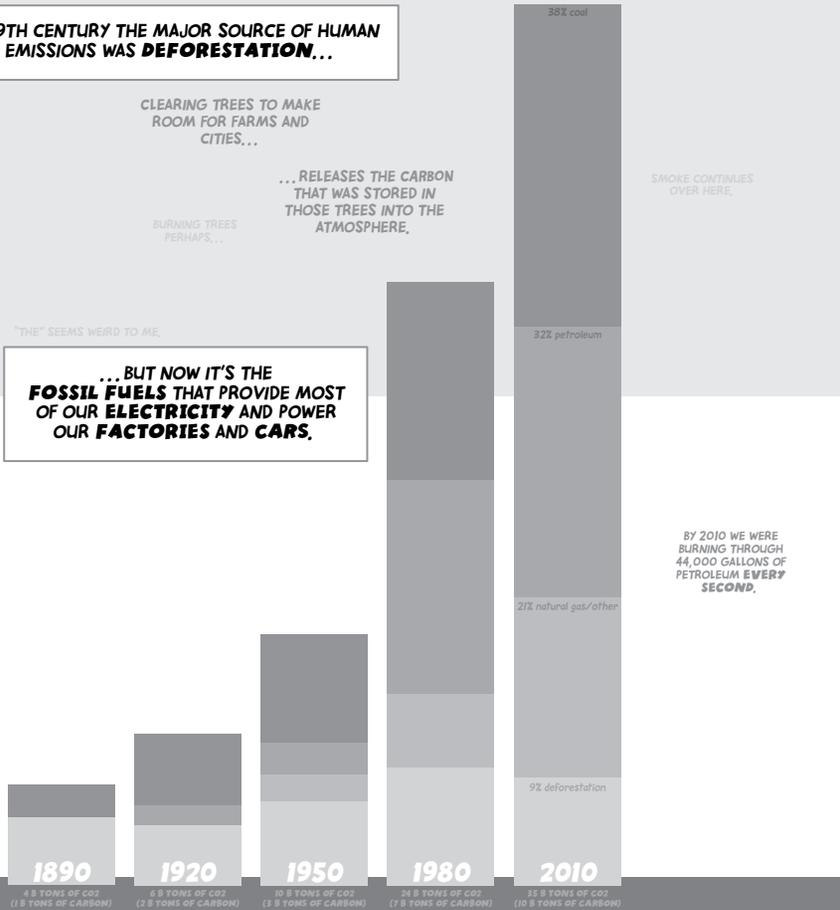
BURNING TREES PERHAPS...

... 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,

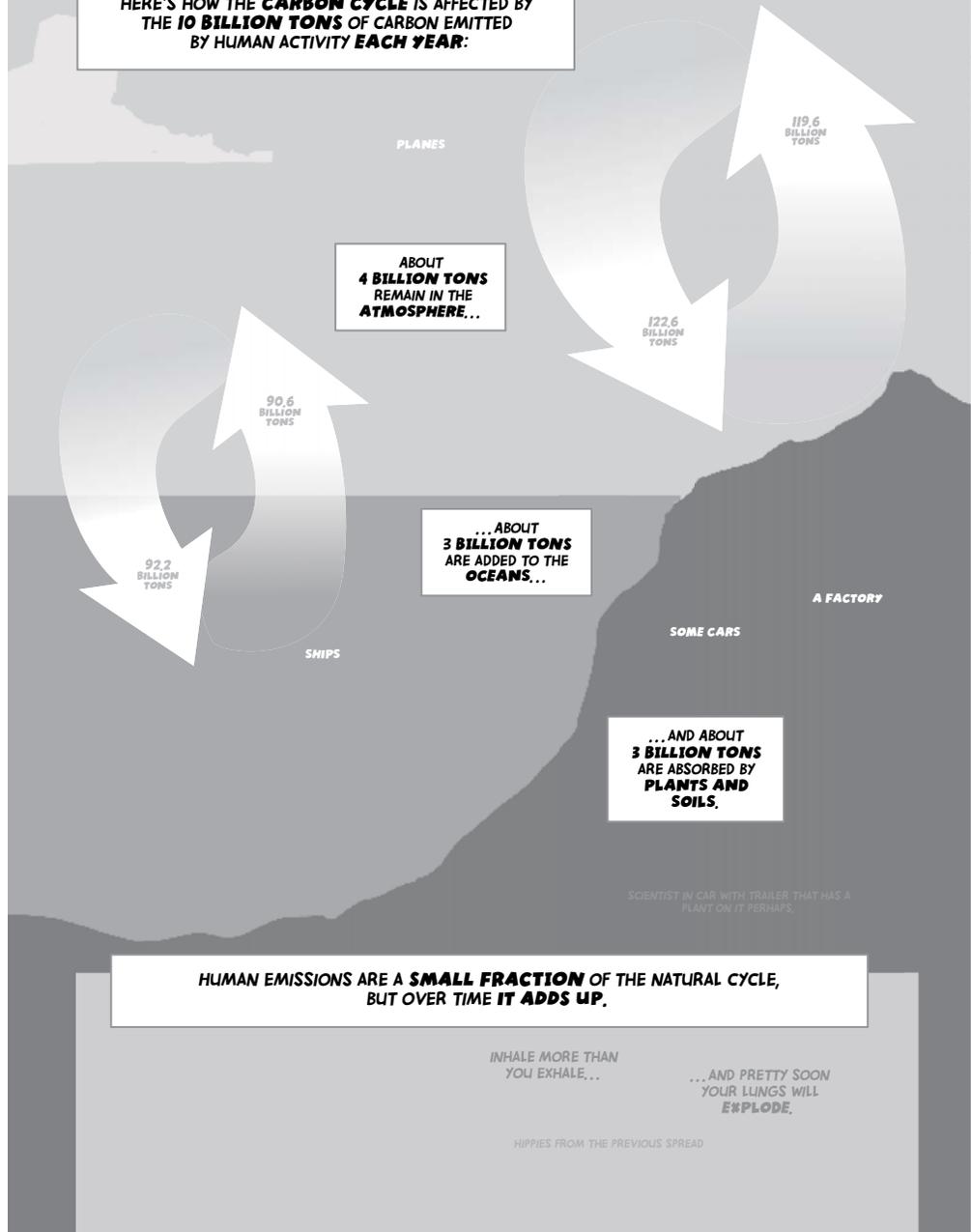
... AND BY OTHER **CARBON SINKS** SUCH AS THE **OCEANS...**

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**:



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

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

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

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 **EXPLODE**,

HIPPIES FROM THE PREVIOUS SPREAD

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

WHAT DID CO2 CONCENTRATIONS LOOK LIKE BEFORE 1958?

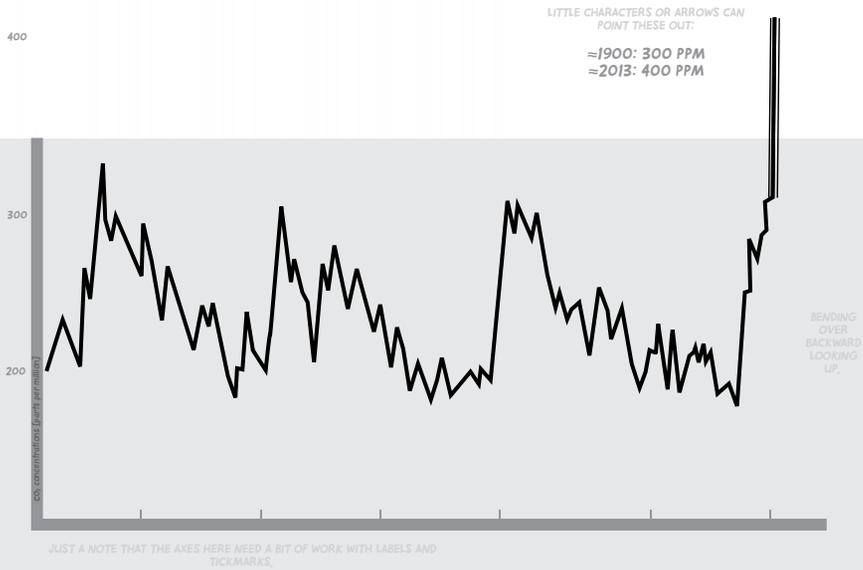
... BY STUDYING THE AMOUNT OF CO2 TRAPPED IN **ICE CORES.**

WE LEARNED ABOUT THESE IN CHAPTER 3.

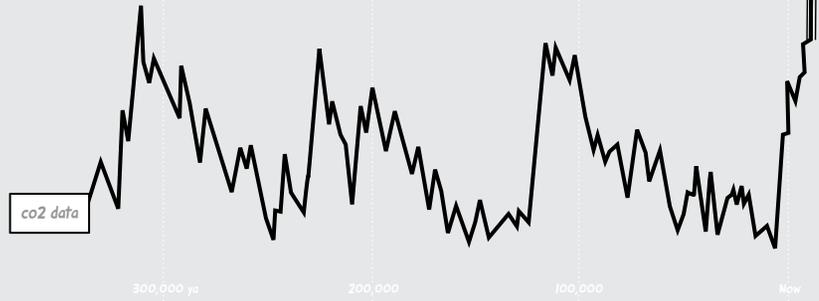
HOLDING ICE CORE,

LOOKING LEFT,

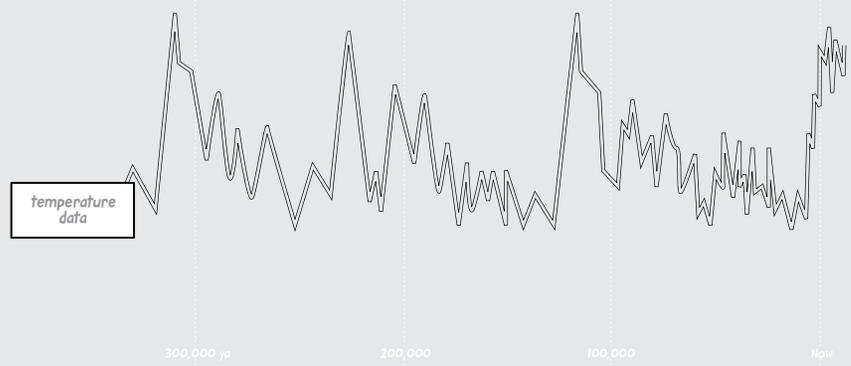
AS YOU CAN SEE, **TODAY'S LEVELS ARE OFF THE CHARTS COMPARED TO THE LAST 350,000 YEARS.**



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**.

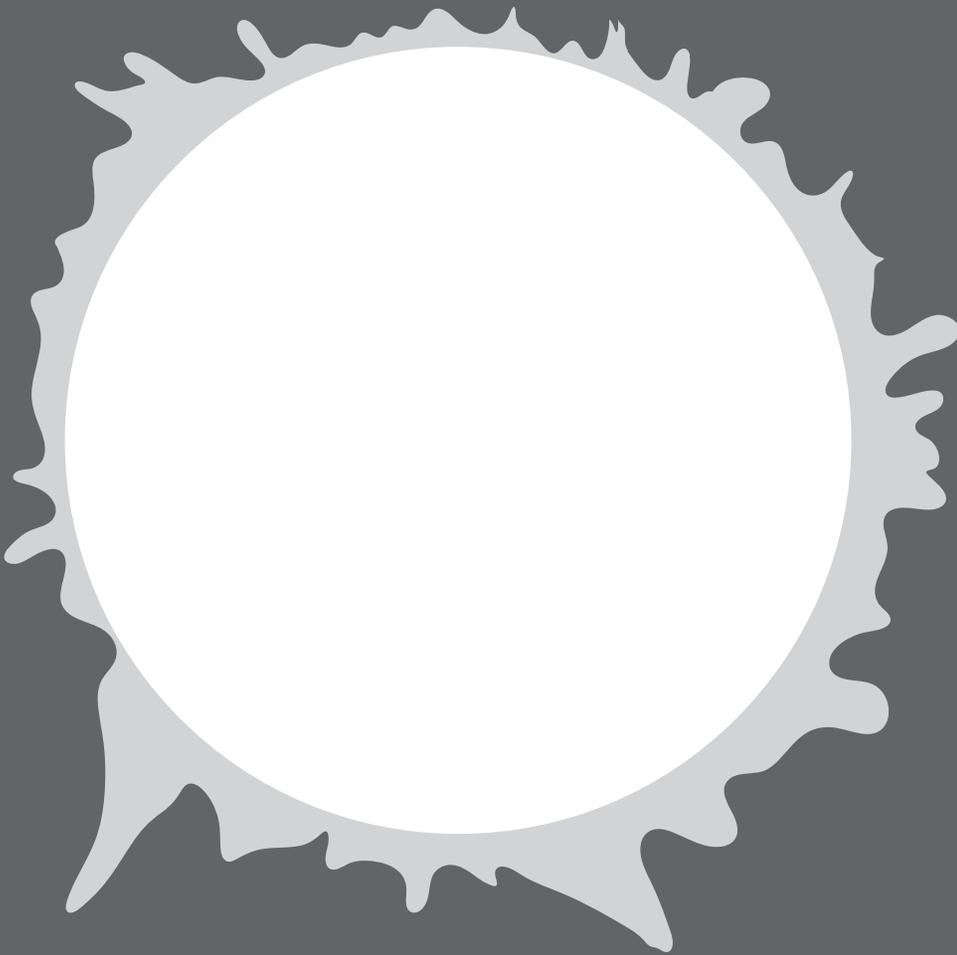
JUST LIKE YOUR HOUSE COOLS
DOWN WHEN YOU OPEN A
WINDOW,

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...

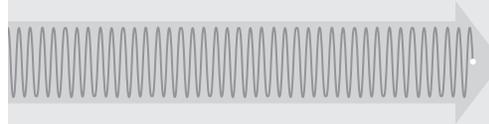
... IS EQUIVALENT TO EACH PERSON ON EARTH RUNNING 100 HAIR DRYERS FOR A WHOLE YEAR.

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.

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



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

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 (H₂O)



CARBON DIOXIDE (CO₂)



METHANE (CH₄),



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)**...

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

WEARING EARLY 19TH CENTURY VERSION OF JEANS

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 CO₂ 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**, CO₂ 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 CO₂ 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** CO₂ CONCENTRATIONS...

WHAT IF WE WENT FROM **280 PPM...**
... TO **560 PPM?**

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

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

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.

THIS IS A LITTLE QUIBBLE, MAYBE WE'LL
GET BACK TO IT, MAYBE NOT...

BUT MENTIONING QUANTUM FEELS A
BIT BRANY 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...

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.

... 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 **CHILLANTROL** TO THESE HYPERACTIVE KIDS...

... AND NOT TO THESE ONES,

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

I'D PREFER SOMETHING FLUMMIER THAN DIABETICS,

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**.

SURGEONS GENERAL FROM DIFFERENT YEARS, PERHAPS PRESS CONFERENCE WITH SIGN ON PODIUM THAT SAYS THE DATES.

2004:

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

... 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...**

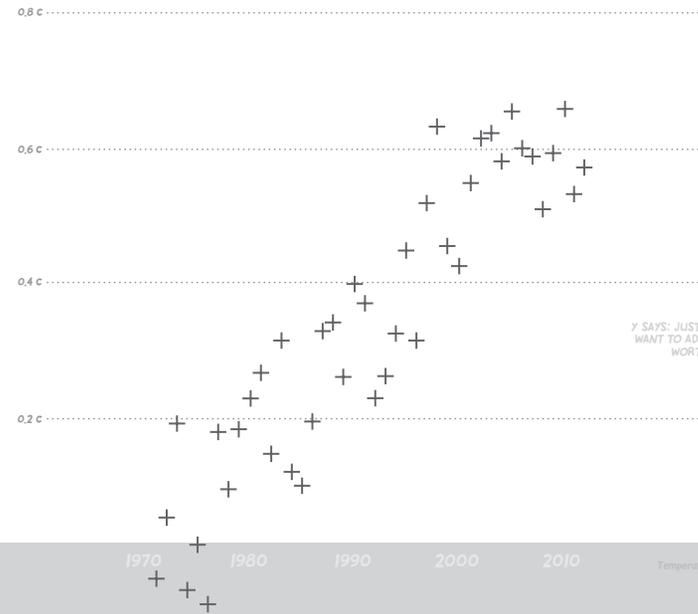
... BUT OUR PREDICTIONS WERE **GREAT**.

(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,

LESS ENERGY ESCAPING INTO THE STRATOSPHERE AND INTO SPACE?

YUP,

OLD BRAINSTORMS:
SOMETHING FUNNY LIKE,
MORE WARMING ON MY HAIRY HEAD...
THAN ON MY BALD ONE?
OR A GAG ABOUT THEIR FASHION.

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,

ONLY ONE PERSON HATES THE BUTLER...

... AND HAS KEYS TO THE KITCHEN...

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

IT WASN'T ME, IT WAS QUEEN VICTORIA,

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 = INTERGOVERNMENTAL 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 = NON-GOVERNMENTAL 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 CARIBBEAN, INDONESIA, IRELAND, MALAYSIA, NEW ZEALAND, SWEDEN

A NOTE TO THOSE WHO MAY OBJECT TO SINGULAR DATA: WE'RE FOLLOWING THE WALL STREET JOURNAL AND THE GUARDIAN UK. IF THOSE TWO PUBLICATIONS CAN AGREE ON SOMETHING, THERE MUST BE SOMETHING TO IT.

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:
DETECTIVE CHARACTER INVOLVED HERE,

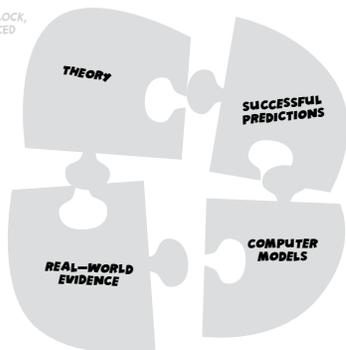
KIDS

... 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.

A PIED FLYCATCHER, AND IT'S ONLY APRIL 10!

[OR YB COULD FIND AN ACCURATE DATE HERE.]

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.

7 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 BAW, 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 FLYING WINDMILLS...

... OR CARBON-EATING TREES...

... 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.

#MAYTRE 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.)

7 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

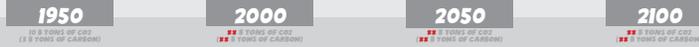
AND

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 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).

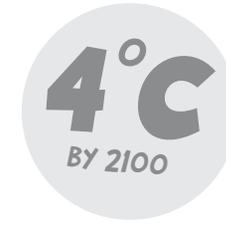
CO2 concentrations (parts per million)

8 200,000 ya 100,000 Now

WORDSMITH, I DON'T LIKE THIS PASSIVE 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 1



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**.

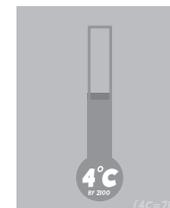
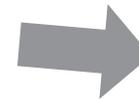
MEH,

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...



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.**

PARENT READING TO SMALL CHILD AT NIGHT TIME:

OPENING UP THE BOOK HERE,



BOOK WITH 4 ON IT.

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, So 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.