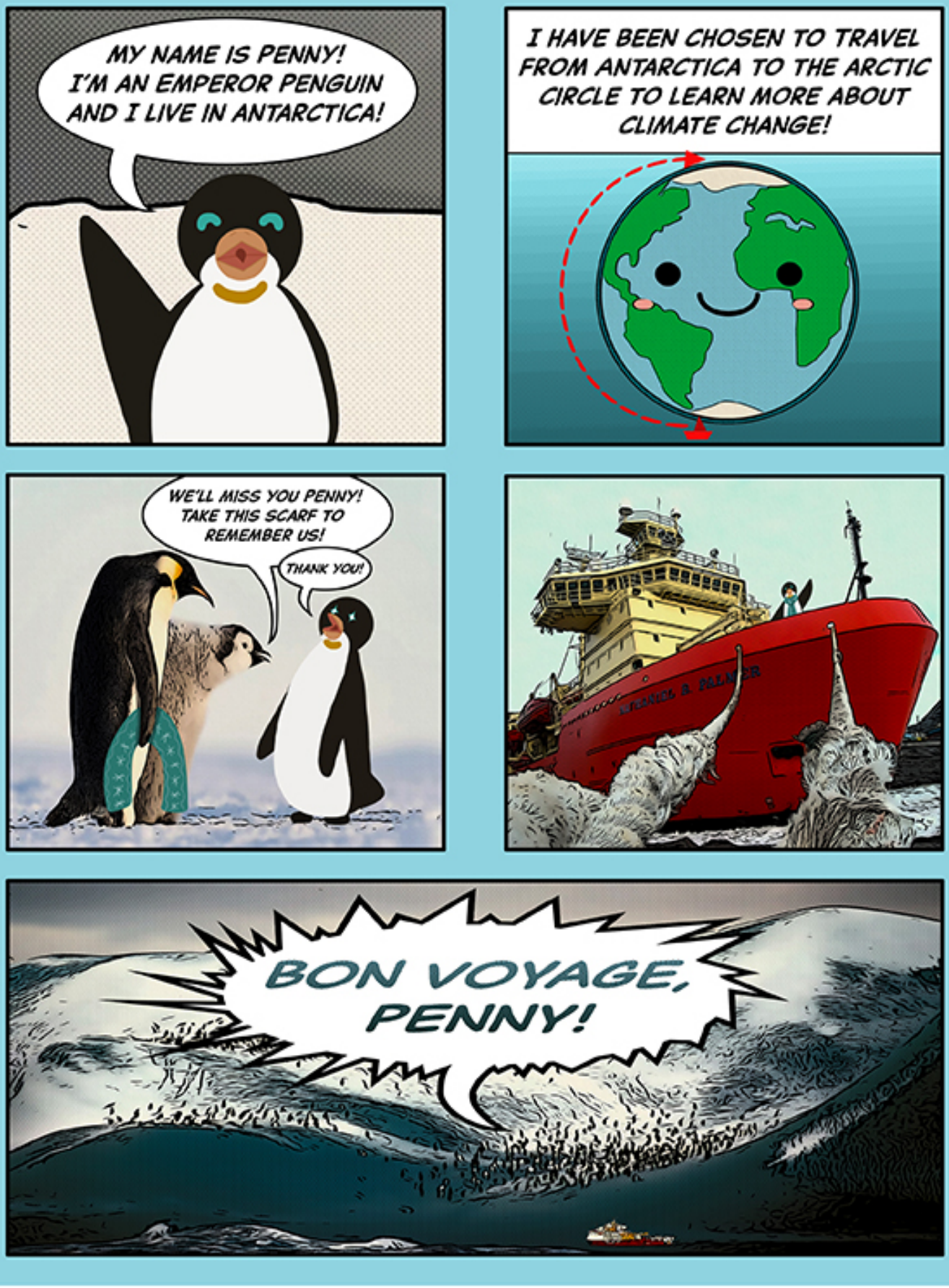

PENNY'S ADVENTURE IN
NAVIGATING THE NEW ARCTIC

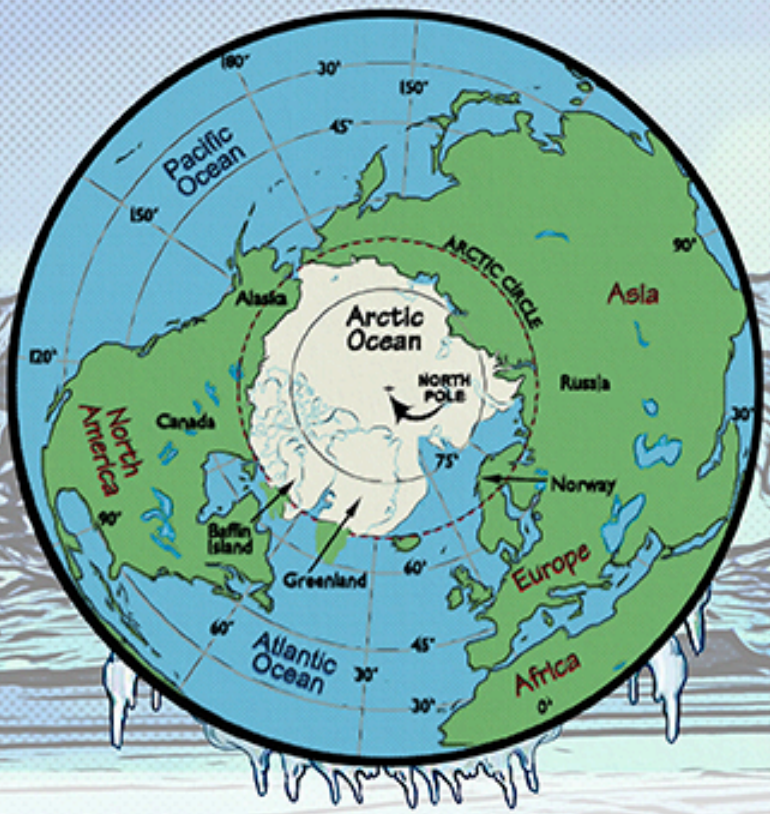
THE POLAR STEAM PROJECT: NAVIGATING THE NEW ARCTIC FENNOSCANDIA PROJECT

THIS IS A MULTI-PRONGED SCIENTIFIC RESEARCH PROJECT THAT IS CENTERED AROUND HOW CLIMATE CHANGE IS AFFECTING THE ARCTIC CIRCLE, FOCUSING ON IMPROVING THE UNDERSTANDING OF CLIMATE CHANGE IN THE ARCTIC, ENHANCING RESEARCH, AND ENABLING RESILIENT AND SUSTAINABLE COMMUNITIES.

THE RESEARCH GOALS ARE TO OBSERVE HOW THE INFRASTRUCTURE AND ACTIVITIES OF PEOPLE INTERACT WITH THE ECOSYSTEM AS WELL AS EDUCATE OTHERS ABOUT THE IMPACTS OF CLIMATE CHANGE IN THE ARCTIC ON MULTIPLE SCALES.

THE GOAL OF THIS COMIC IS TO EDUCATE PEOPLE ABOUT THE RESEARCH BEING CONDUCTED IN THE ARCTIC AND THE OUTCOMES OF THAT RESEARCH.

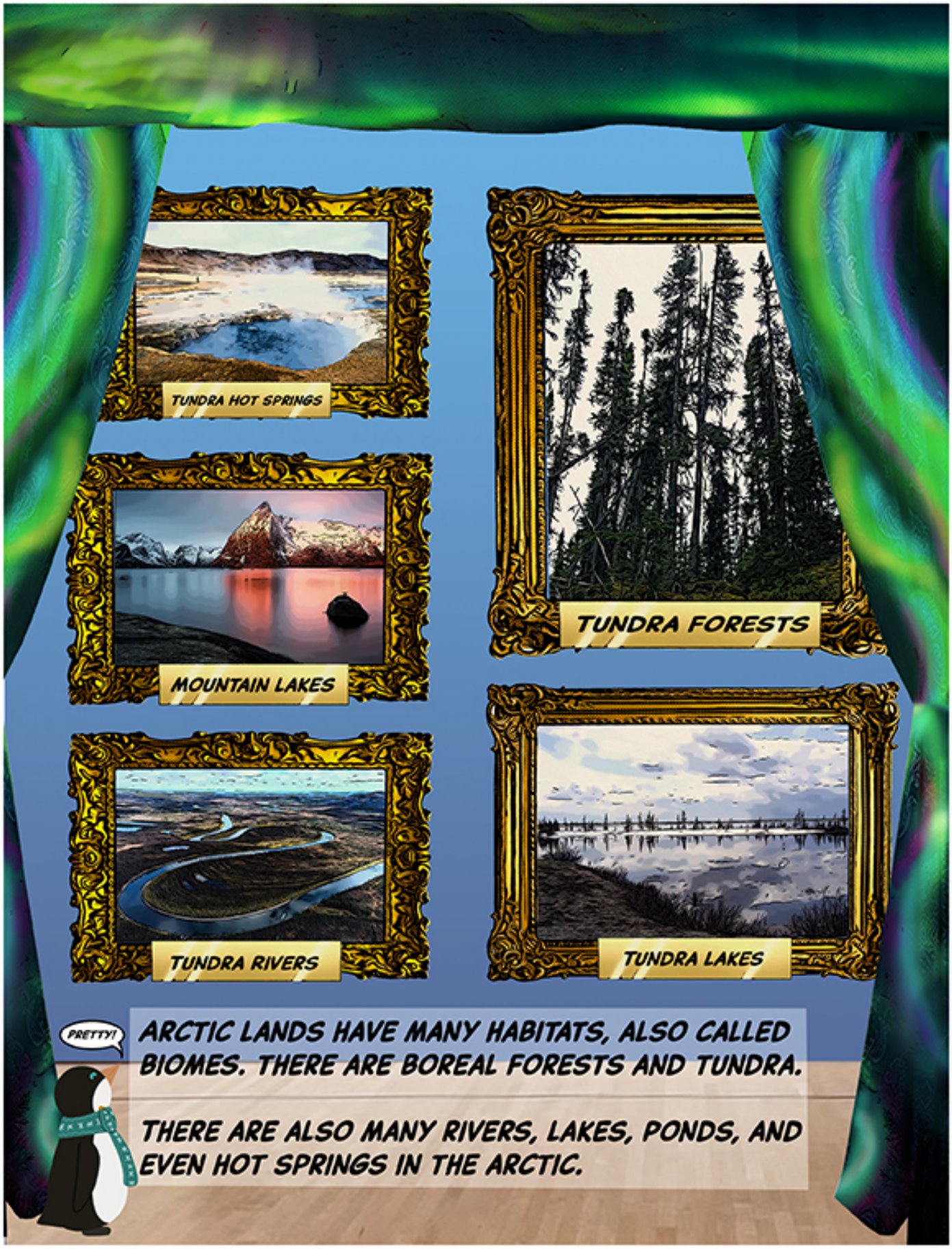

MY NAME IS PENNY! I'M AN EMPEROR PENGUIN AND I LIVE IN ANTARCTICA!
I HAVE BEEN CHOSEN TO TRAVEL FROM ANTARCTICA TO THE ARCTIC CIRCLE TO LEARN MORE ABOUT CLIMATE CHANGE!
WE'LL MISS YOU PENNY! TAKE THIS SCARF TO REMEMBER US!
THANK YOU!
BON VOYAGE, PENNY!



THE ARCTIC IS AT THE TOP OF OUR PLANET. IT IS NOT A CONTINENT LIKE NORTH AMERICA.

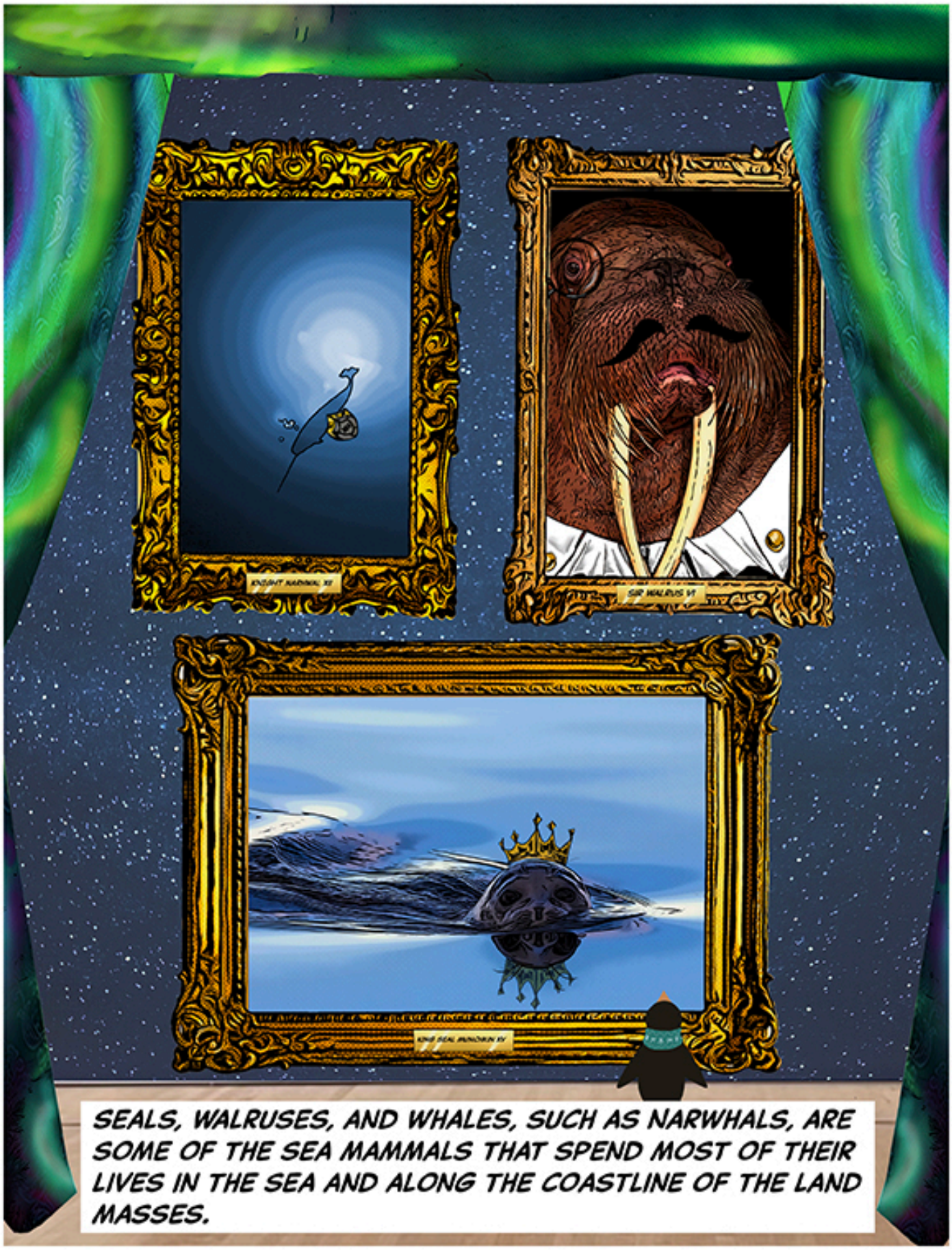
IT'S REALLY AN OCEAN WITH THICK ICE COVERING IT IN THE WINTER. IN THE SUMMER, THE ICE THINS AND FLOATS AROUND.

THE ARCTIC ALSO INCLUDES THE NORTHERN EDGES OF LAND MASSES SURROUNDING THE OCEAN.


TUNDRA HOT SPRINGS
TUNDRA FORESTS
MOUNTAIN LAKES
TUNDRA RIVERS
TUNDRA LAKES
PRETTY!
ARCTIC LANDS HAVE MANY HABITATS, ALSO CALLED BIOMES. THERE ARE BOREAL FORESTS AND TUNDRA.
THERE ARE ALSO MANY RIVERS, LAKES, PONDS, AND EVEN HOT SPRINGS IN THE ARCTIC.


POLAR BEARS
MUSKOX
MOOSE
REINDEER
ARCTIC WOLF
MANY ANIMALS LIVE IN THE ARCTIC.

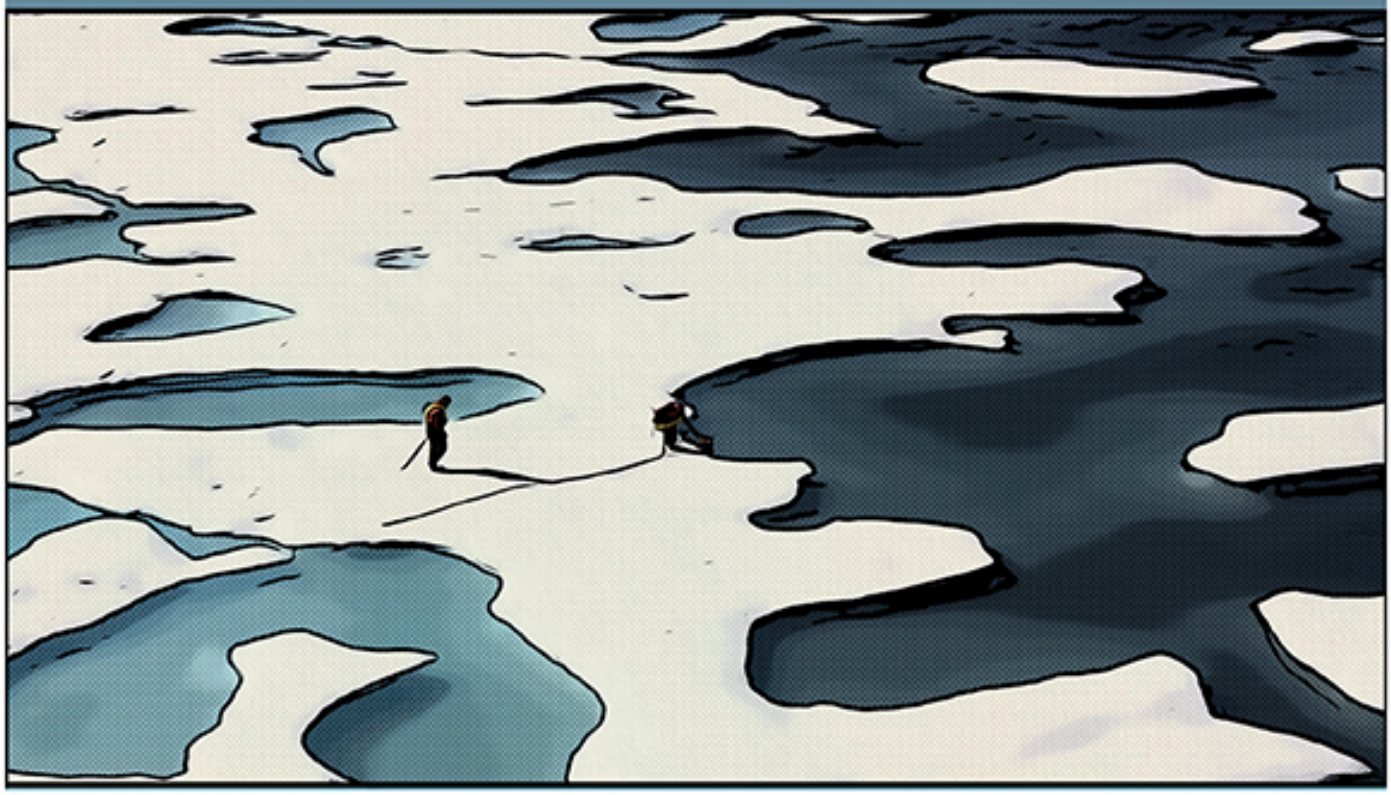

ARCTIC HARE
LEMMING
SCARF BUDDIES!
ARCTIC FOX
BEAVER
SMALLER ANIMALS INCLUDE ARCTIC FOXES, RED FOXES, GROUND SQUIRRELS, BEAVERS, SNOWSHOE HARES, LEMMINGS, AND MORE.


SEALS, WALRUSES, AND WHALES, SUCH AS NARWHALS, ARE SOME OF THE SEA MAMMALS THAT SPEND MOST OF THEIR LIVES IN THE SEA AND ALONG THE COASTLINE OF THE LAND MASSES.


SNOWY OWL
ARCTIC TERN
IVORY GULL
MANY BIRDS ARE PART OF THE ARCTIC ECOSYSTEM. YOU CAN FIND SNOWY OWLS, TUNDRA SWANS, ARCTIC TERNS, AND OTHER ARCTIC BIRDS, AS WELL AS MANY BIRDS THAT MIGRATE TO THE ARCTIC FROM VERY FAR AWAY TO MAKE NESTS DURING THE SUMMER.

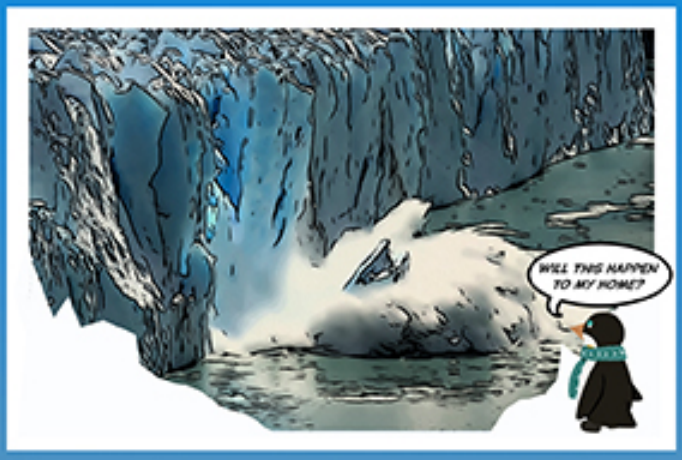
PEOPLE HAVE LIVED IN THE ARCTIC AND HAVE FOR THOUSANDS OF YEARS. SOME OF THEM MAY HAVE CROSSED A LAND BRIDGE IN THE BERING SEA DURING THE LAST ICE AGE. THESE EARLY INDIGENOUS PEOPLE CONTINUED INTO WHAT IS NOW CALLED NORTH AMERICA.

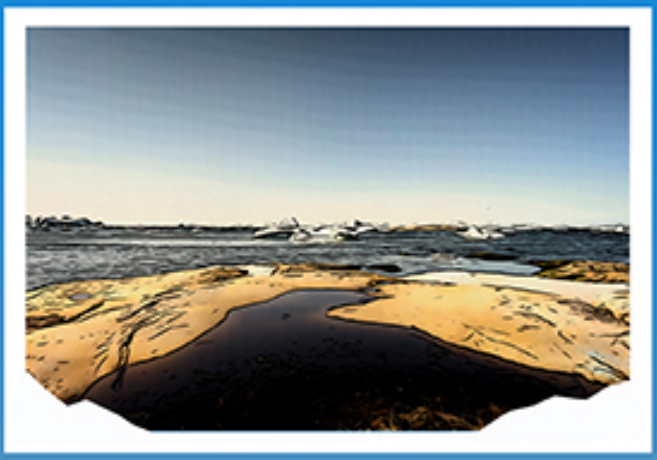
OTHERS STAYED IN THE ARCTIC AND THEIR DESCENDANTS LIVE THERE TODAY!



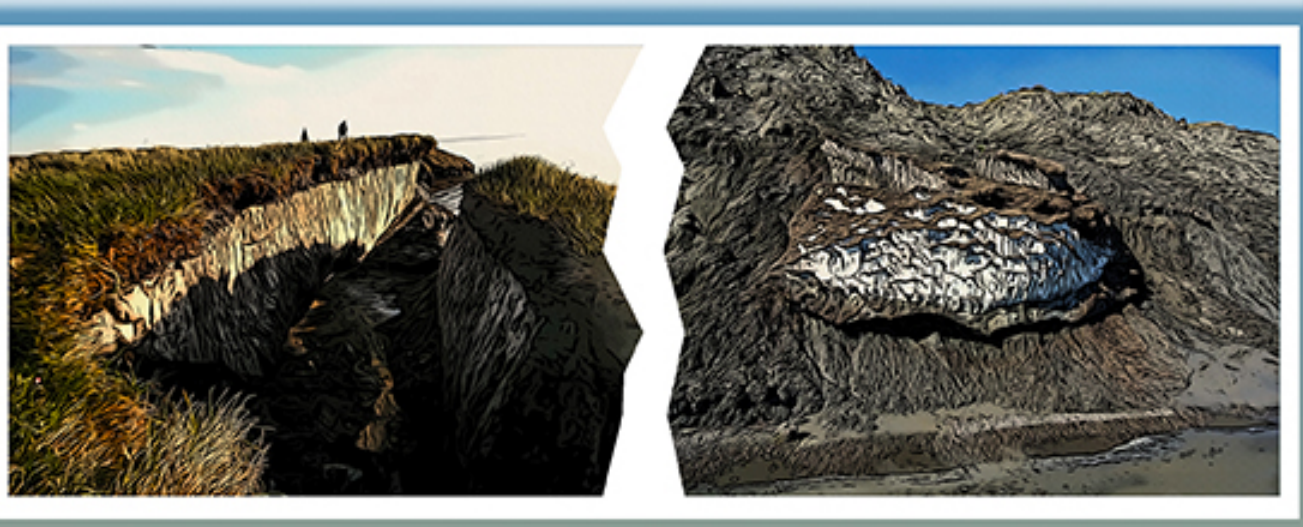
ANOTHER GROUP OF HUMANS HAS LIVED IN AN AREA CALLED FENNOSCANDIA FOR THOUSANDS OF YEARS. FENNOSCANDIA IS A REGION IN NORTHERN EUROPE THAT INCLUDES THE COUNTRIES OF NORWAY, FINLAND, AND SWEDEN. THESE PEOPLE CALL THEMSELVES THE SÁMI.

REINDEER HAVE ALWAYS BEEN IMPORTANT TO THE SÁMI PEOPLE, FIRST AS HUNTED PREY, THEN AS HERD ANIMALS. NOWADAYS, THE SÁMI PEOPLE HAVE MANY DIFFERENT JOBS, WITH SOME CONTINUING TO HERD REINDEER AS THEIR ANCESTORS HAVE FOR HUNDREDS OF YEARS.

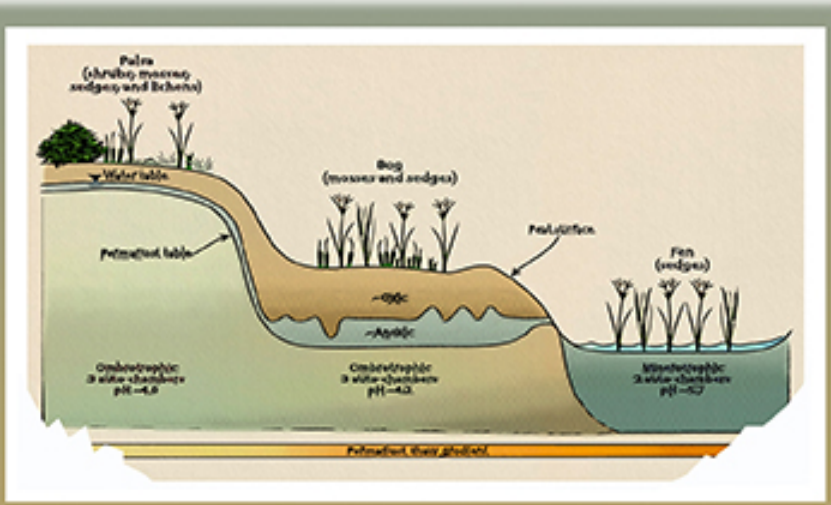


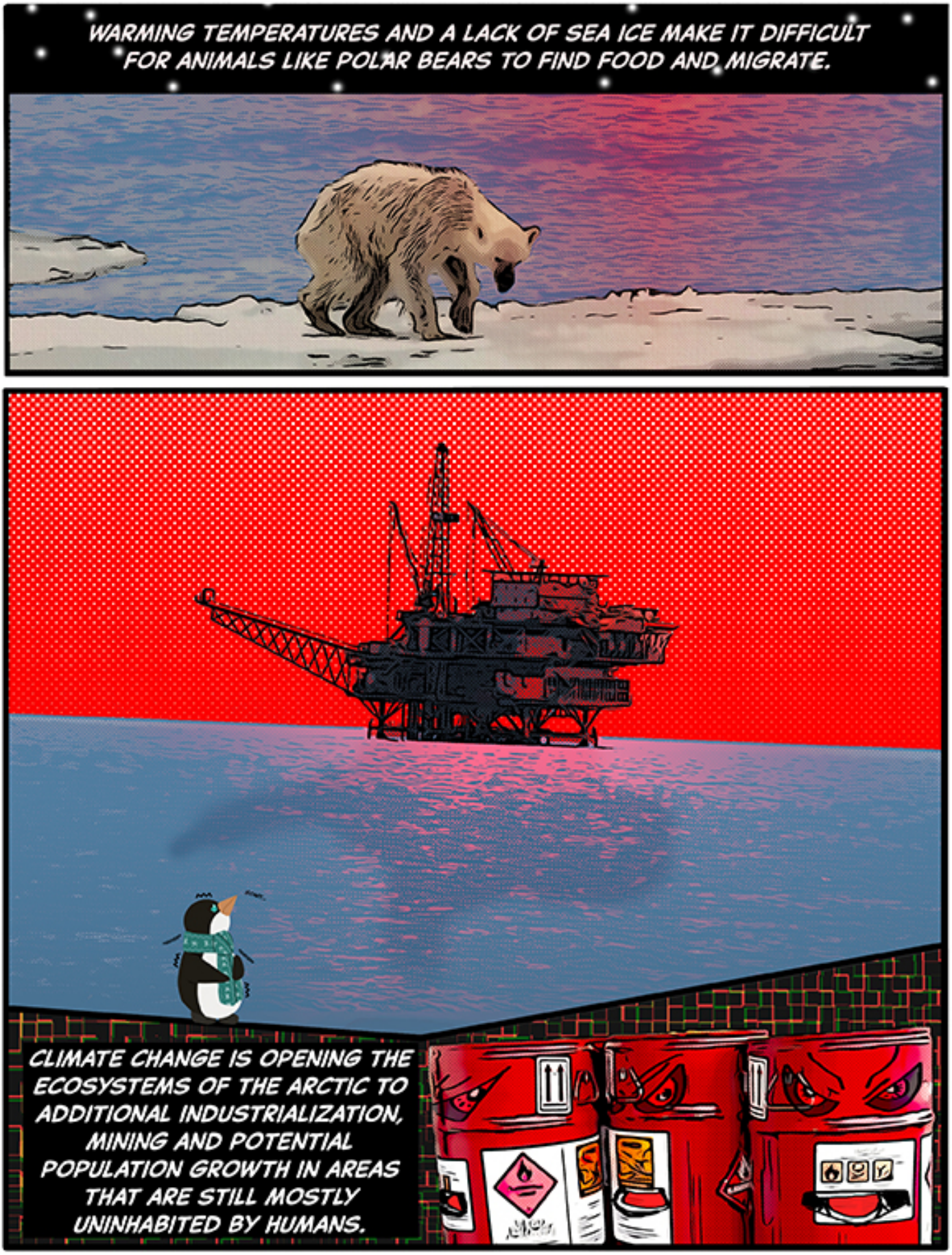


TODAY, CLIMATE CHANGE IS ALTERING THE ARCTIC. AS THE ARCTIC WARMS, THE AMOUNT OF SEA ICE IN THE ARCTIC OCEAN IS DECLINING, WHICH HAS A HUGE IMPACT ON THE SURROUNDING OCEAN AND LAND ECOSYSTEMS.



THE PERMAFROST FOUND IN THE TUNDRA, WHICH IS A LAYER OF FROZEN SOIL AND ICE THAT STAYS FROZEN ALL YEAR, IS THAWING UNDER WARMER CLIMATES.




WARMING TEMPERATURES AND A LACK OF SEA ICE MAKE IT DIFFICULT FOR ANIMALS LIKE POLAR BEARS TO FIND FOOD AND MIGRATE.
CLIMATE CHANGE IS OPENING THE ECOSYSTEMS OF THE ARCTIC TO ADDITIONAL INDUSTRIALIZATION, MINING AND POTENTIAL POPULATION GROWTH IN AREAS THAT ARE STILL MOSTLY UNINHABITED BY HUMANS.

INDIGENOUS PEOPLE, LIKE THE SÁMI, ARE AFFECTED TOO. EXTREMES IN WEATHER AND EXTRACTION OF NATURAL RESOURCES IMPACT THEIR ABILITY TO HERD.

SÁMI ♥

SO, WHAT SHOULD BE DONE?

REDUCING THE USE OF FOSSIL FUELS DECREASES CARBON EMISSIONS, HELPING TO MITIGATE CLIMATE CHANGE. INCREASING THE USE OF RENEWABLE, GREEN ENERGY HELPS PROTECTS THE EARTH'S ENVIRONMENT AND ECOSYSTEMS.

BUT, EVEN DOING THAT CAN IMPACT THE ARCTIC, THE PEOPLE, AND THE ANIMALS WHO CALL THE ARCTIC HOME.

WHY IS THAT?

FORTUNATELY, THERE ARE MANY TEAMS OF SCIENTISTS LOOKING FOR SOLUTIONS.

THESE ARE THE STORIES OF THREE OF THOSE SCIENTISTS.

DR. PETER UNGAR

DR. MARY HESKEL

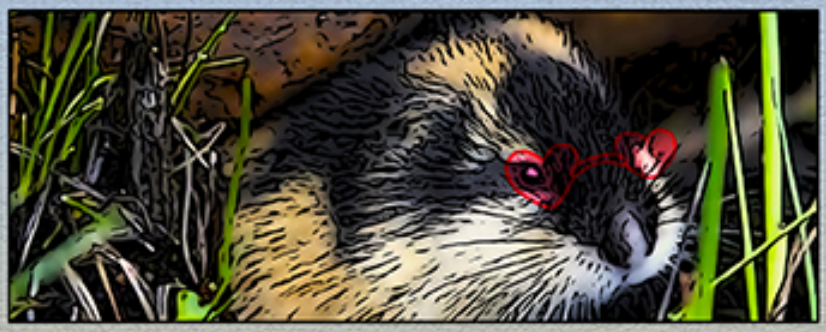
DR. ALEKSEY SHESHUKOV

MEET
DR. PETER UNGAR.

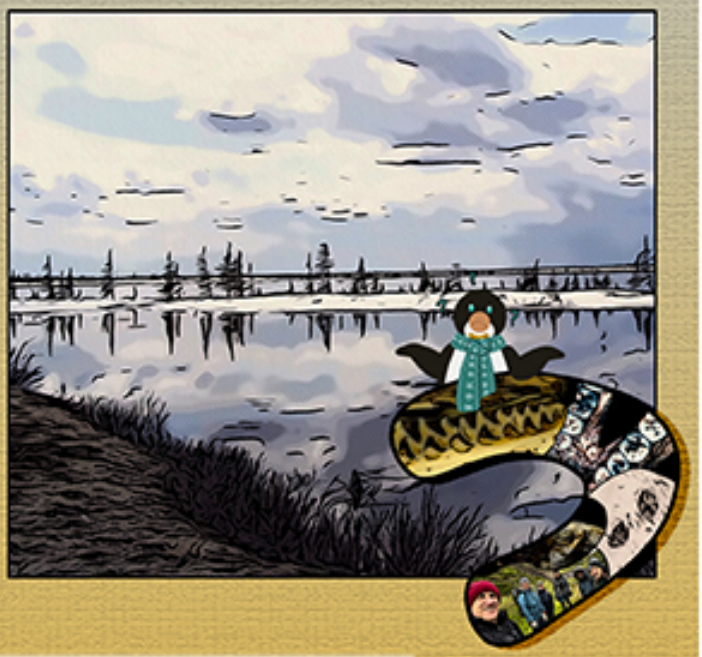
HE'S PART OF THE NAVIGATING
THE NEW ARCTIC RESEARCH TEAM.
DR. UNGAR HAS A PH.D. IN PALEOANTHROPOLOGY.

IN THE PAST,
HE INVESTIGATED HOW THE FOOD
THAT ANCIENT HUMANS ATE
CONTRIBUTED TO THE EVOLUTION
OF OUR SPECIES.

NOW, DR. UNGAR AND HIS FRIENDS ARE FOCUSED ON HOW ANIMALS, SUCH AS REINDEER AND SMALL RODENTS, LIKE LEMMINGS, ARE RESPONDING TO CLIMATE CHANGES IN THE ARCTIC.



PART OF HIS RESEARCH TAKES PLACE IN A UNIVERSITY LAB AND THE OTHER PART IN THE ARCTIC CIRCLE.



SO, WHAT DOES A DAY OF RESEARCH IN THE ARCTIC CIRCLE LOOK LIKE FOR DR. UNGAR?

BELIEVE IT OR NOT, DR. UNGAR COUNTS POOP TO GIVE HIM AN IDEA OF HOW OFTEN ANIMALS VISIT AN AREA. HE CAN TELL WHETHER ANIMALS OF GIVEN SPECIES PREFER TO TRAVEL THROUGH AND FEED IN SPECIFIC AREAS, OR WHETHER THE ANIMALS AVOID A LOCATION.

FOR EXAMPLE, HE IS LOOKING AT HIGHER AND LOWER ELEVATION AREAS AND COMPARING THE AREAS THAT HAVE WIND FARMS AND THOSE WITHOUT WIND FARMS. DR. UNGAR AND HIS SCIENTIST FRIENDS WANT TO SEE HOW THE WINDFARM INFRASTUCTURE AFFECTS THE MOVEMENT PATTERNS OF ANIMALS, ESPECIALLY REINDEER.

DR. UNGAR WANTS TO KNOW HOW THE WIND FARMS AND OTHER HUMAN INFASTRUCTURE, SUCH AS ROADS AND MINES, ARE AFFECTING THE BEHAVIORS AND MOVEMENTS OF REINDEER. AT THIS TIME, NO ONE KNOWS HOW MUCH IMPACT THE WIND FARMS MIGHT HAVE ON THE LIVELIHOODS OF HERDERS OR THE LIVES OF OTHER ANIMALS IN DIFFERENT PLACES AND AT DIFFERENT TIMES.

DR. UNGAR THINKS THAT UNDERSTANDING THE IMPACT OF HUMAN INFRASTRUCTURE ON ANIMALS IN THE ARCTIC CIRCLE CAN HELP LOCAL PEOPLE, GOVERNMENTS, AND INDUSTRIES PLAN FUTURE LOCATIONS FOR INFASTRUCTURE AND HELP CONSERVATION EFFORTS.

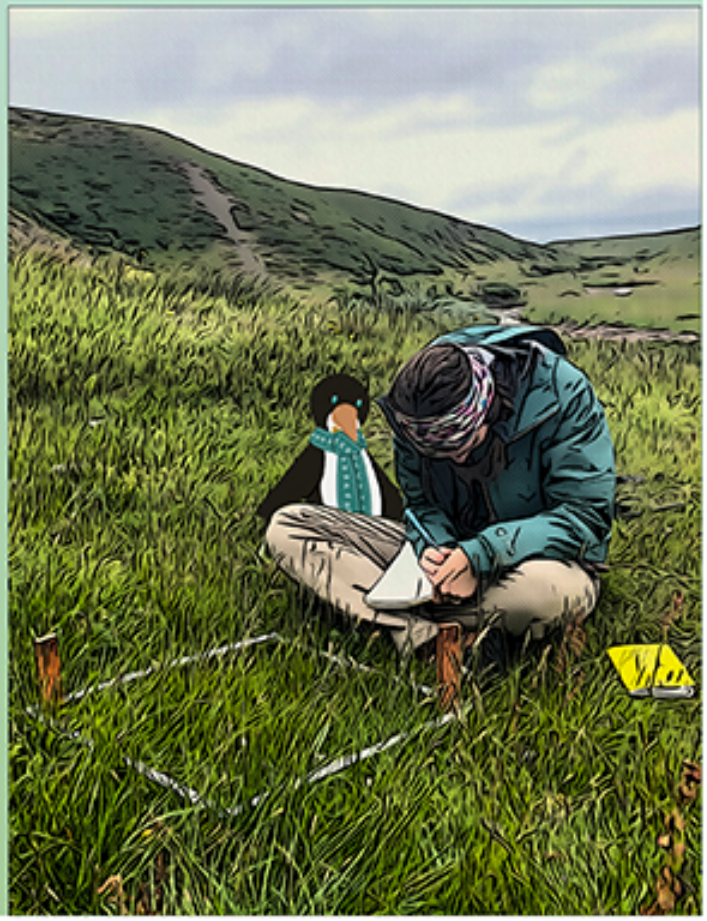
MEET DR. MARY HESKEL

SHE, TOO, IS PART OF THE NAVIGATING THE NEW ARCTIC TEAM. DR. HESKEL HAS A PH.D. IN ECOLOGY.

SHE STUDIES HOW PLANTS USE AND STORE CARBON IN ECOSYSTEMS THAT ARE IMPACTED BY CLIMATE CHANGE.

DR. HESKEL TRAVELED TO THE ARCTIC CIRCLE TO CONDUCT RESEARCH ON THE BIODIVERSITY OF PLANTS IN THE TUNDRA ECOSYSTEM.

SO, WHAT DOES A DAY OF RESEARCH ABOVE THE ARCTIC CIRCLE LOOK LIKE FOR DR. HESKEL?



IN THE ARCTIC, DR. HESKEL IS INTERESTED IN UNDERSTANDING HOW PLANT NUTRIENTS VARY FOR SMALL RODENTS AS WELL AS LARGE HERBIVORES, LIKE REINDEER.

WHAT'S AN HERBIVORE?

AN HERBIVORE IS AN ANIMAL THAT ONLY EATS PLANT MATTER. REINDEER ARE HERBIVORES, AND SO ARE MANY RODENTS, LIKE LEMMINGS.

PEOPLE CAN BE HERBIVORES TOO, BUT WE USUALLY CALL THEM VEGETARIANS OR VEGANS.

TO LEARN ABOUT PLANT NUTRIENTS, DR. HESKEL AND HER SCIENTIST FRIENDS COLLECTED DOZENS OF PLANT SPECIES WHEN THEY VISITED FENNOSCANDIA. THEN DR. HESKEL MEASURES WHICH PLANTS ARE WHERE AND THEN COLLECTS THEIR LEAVES, STEMS, AND FRUITS. THEN SHE AND THE TEAM USE SPECIALIZED EQUIPMENT THAT MEASURES WHAT THE PLANTS ARE MADE UP OF: THINGS LIKE SUGAR, FIBER, AND OTHER PLANT NUTRIENTS. NEXT, SHE AND THE TEAM COMPARE THE NUTRIENTS IN THE DIFFERENT PLANT SPECIES WITH WHAT IS FOUND IN HERBIVORE POOP.

DR. HESKEL HAS TO GATHER LOTS OF PLANTS.
SHE USES PAPER BAGS TO STORE PLANTS WHEN THEY ARE DRYING.
SHE ALSO WARMS THEM IN AN OVEN AT LOW TEMPERATURES TO DRY THEM OUT.
PLUS, PAPER BAGS WON'T MELT LIKE PLASTIC MIGHT.

ANOTHER PROJECT SHE AND OTHER SCIENTISTS ARE WORKING ON IS INVESTIGATING THE ROLE OF SMALL RODENTS ON PLANT DIVERSITY.

SMALL RODENTS, SUCH AS LEMMINGS, USE GRASSES TO EAT AND BUILD THEIR HOMES FOR THE WINTER.

THEY USE THEIR TEETH TO CUT GRASS AND THEIR CLAWS TO DIG AROUND IN THE SOIL.

THE PLANT DISTURBANCE CAUSED BY THE RODENTS MIGHT ENCOURAGE THE GROWTH OF SOME PLANT SPECIES, BUT IT MIGHT ALSO DISCOURAGE PLANT GROWTH IN OTHER PLANT SPECIES.

HOW MANY RODENTS DOES IT TAKE TO ENCOURAGE OR DISCOURAGE PLANT GROWTH? HOW DO YOU COUNT THE RODENTS? THERE IS SPECIAL EQUIPMENT TO DO JUST THAT!

ALONG A WELL-WORN PATH USED BY RODENTS, SCIENTISTS PLACE A SPECIAL BOX WITH A CAMERA INSIDE IT.

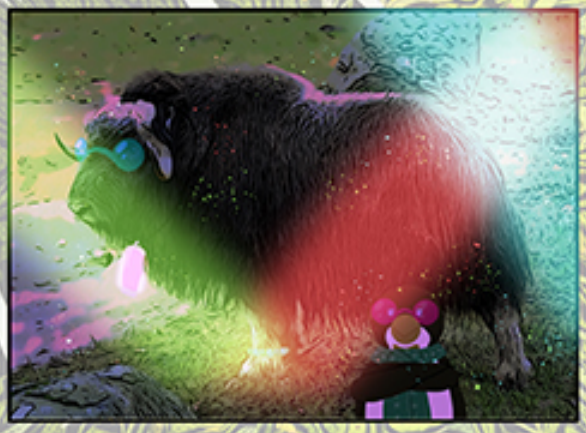
THEY DISGUISE THE BOX WITH DIRT, PLANTS, AND ROCKS.

WHEN THE RODENTS RUN ALONG THE PATH...

THEY PASS THROUGH THE BOX, AND THEIR PHOTOGRAPH IS TAKEN!

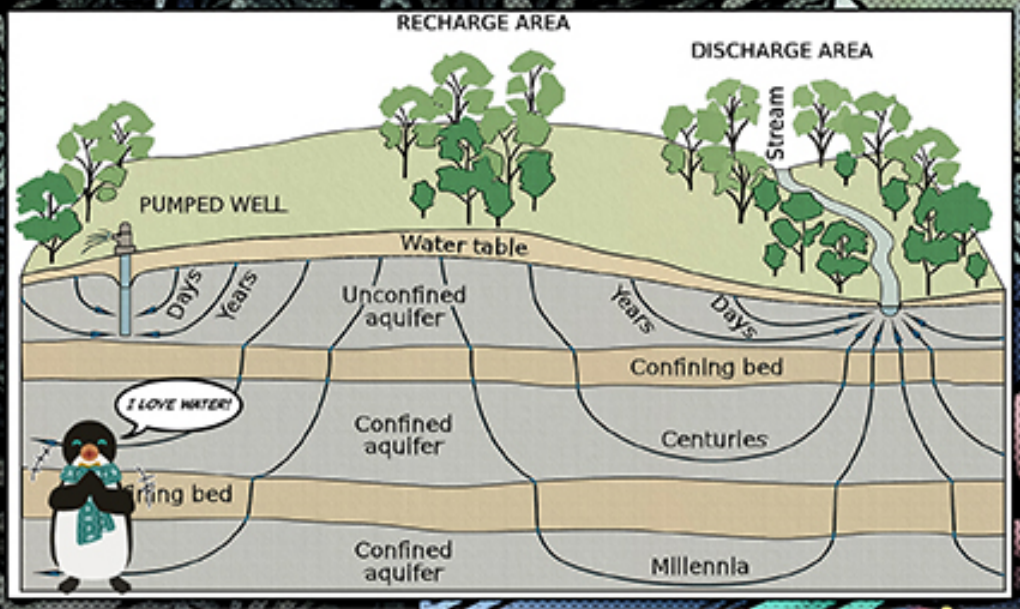
AFTER A PERIOD OF TIME, THE SCIENTISTS DOWNLOAD THE PHOTOS AND COUNT HOW MANY RODENTS WENT THROUGH THE BOX. THAT NUMBER CAN LATER BE EXTRAPOLATED TO GET AN ESTIMATE OF HOW MANY RODENTS ARE IN THE AREA.

DR. HESKEL AND THE RESEARCH TEAM AIM TO UNDERSTAND HOW THE BIODIVERSITY OF PLANTS IN THE ARCTIC CONTRIBUTES TO THE DIET OF IMPORTANT HERBIVORES – BOTH SMALL AND LARGE. SHE WANTS TO UNDERSTAND HOW AND WHERE THESE PLANTS MIGHT GROW AS CLIMATE CHANGE WARMS THE ARCTIC.



MEET DR. ALEKSEY SHESHUKOV

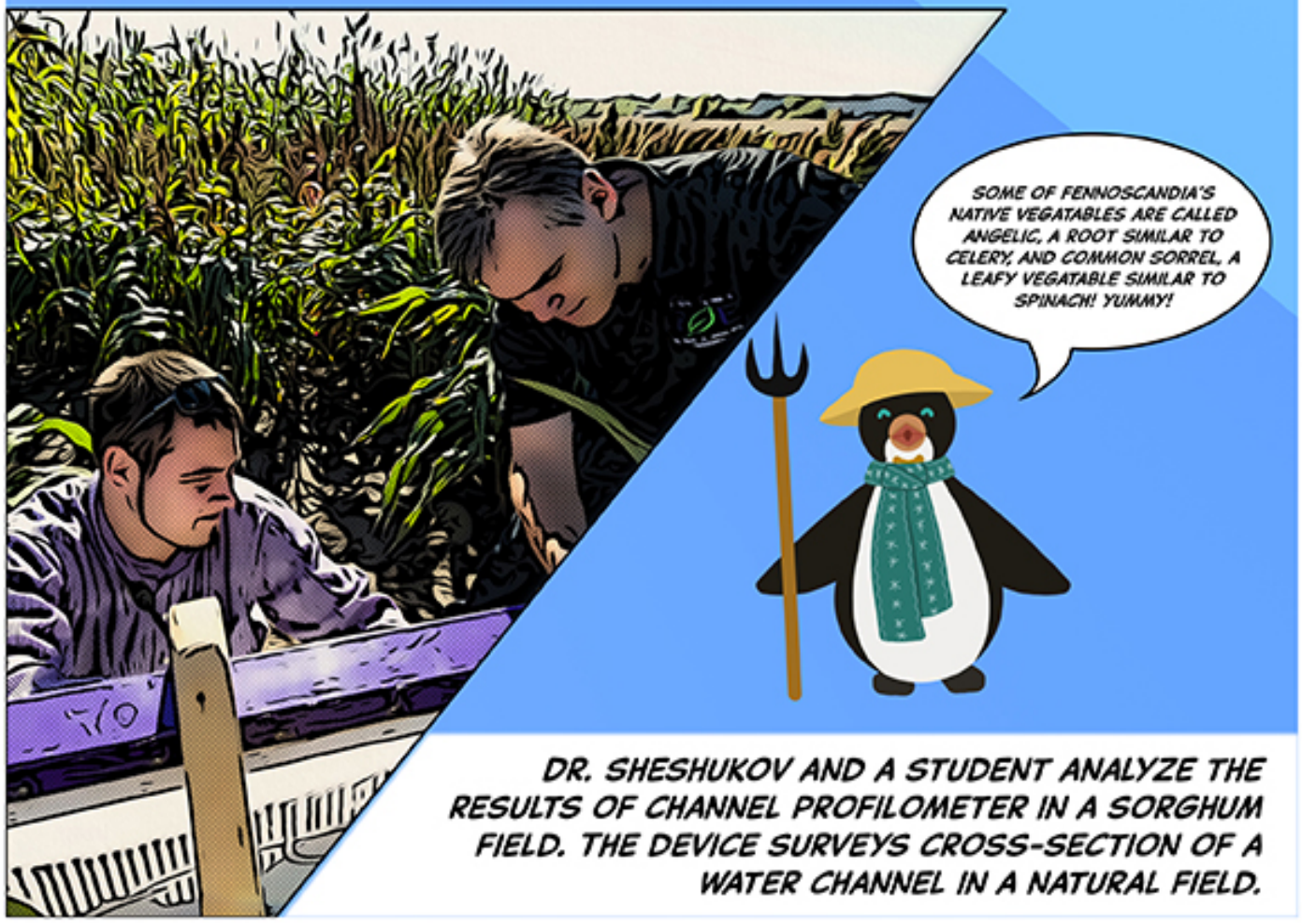
HE IS ALSO A PART OF THE NAVIGATING THE NEW ARCTIC TEAM. DR. SHESHUKOV HAS A PH.D. IN FLUID MECHANICS.



DR. SHESHUKOV SPECIALIZES IN HYDROLOGY (THE STUDY OF WATER) AND RESEARCHES WATERSHEDS. A WATERSHED IS AN AREA OF LAND THAT MOVES, DRAINS, OR "SHEDS" WATER INTO A BODY OF WATER. SOME WATER STAYS ON THE SURFACE (LIKE A LAKE) WHILE SOME WATER FILTERS UNDERGROUND INTO WHAT IS CALLED AN AQUIFER.

DR. SHESHUKOV STUDIES WAYS TO DEVELOP SUSTAINABLE PRACTICES IN AGRICULTURAL ECOSYSTEMS. SUSTAINABLE PRACTICES ARE VERY IMPORTANT FOR WATERSHED MANAGEMENT AND RESTORATION. HE INSTALLS METEOROLOGICAL (WEATHER) AND HYDROLOGICAL (WATER) EQUIPMENT. THE EQUIPMENT COLLECTS DATA THAT DR. SHESHUKOV THEN USES TO CREATE COMPUTER MODELS THAT SHOW HOW CLIMATE AND LAND USE IMPACT WATERSHED HYDROLOGY AND WATER QUALITY.

DR. SHESHUKOV TAKES MEASUREMENTS OF A STREAM CHANNEL DEGRADATION WITH A JET EROSION TEST (JET) INSTRUMENT. STREAM BANK EROSION CAUSES PROBLEMS FOR FISH, INVERTEBRATES, AND THE ECOSYSTEM IN BODIES OF WATER.



DR. SHESHUKOV AND A STUDENT ANALYZE THE RESULTS OF CHANNEL PROFILOMETER IN A SORGHUM FIELD. THE DEVICE SURVEYS CROSS-SECTION OF A WATER CHANNEL IN A NATURAL FIELD.

DR. SHESHUKOV AND HIS SCIENTIST FRIENDS WANTED TO MEASURE THE NATURAL PROCESSES IN THE ARCTIC THAT ARE AFFECTED BY CLIMATE CHANGE AND THE EXPANDING HUMAN INFRASTRUCTURE.

THEY DID THIS BY INSTALLING SPECIAL SENSORS IN THE GROUND THAT MEASURED TEMPERATURE, WATER IN THE SOIL, SNOW, AND ENERGY FLUX CHANGES SPECIFIC TO THE FENNOSCANDIA REGION.

THE SENSORS WERE INSTALLED AT DIFFERENT DEPTHS IN THE SOIL AT SEVERAL LOCATIONS. ALL THE SENSORS ARE CONNECTED THROUGH THE CABLES TO A DEVICE THAT LOGS AND RECORDS THE DATA TO A MEMORY DRIVE.

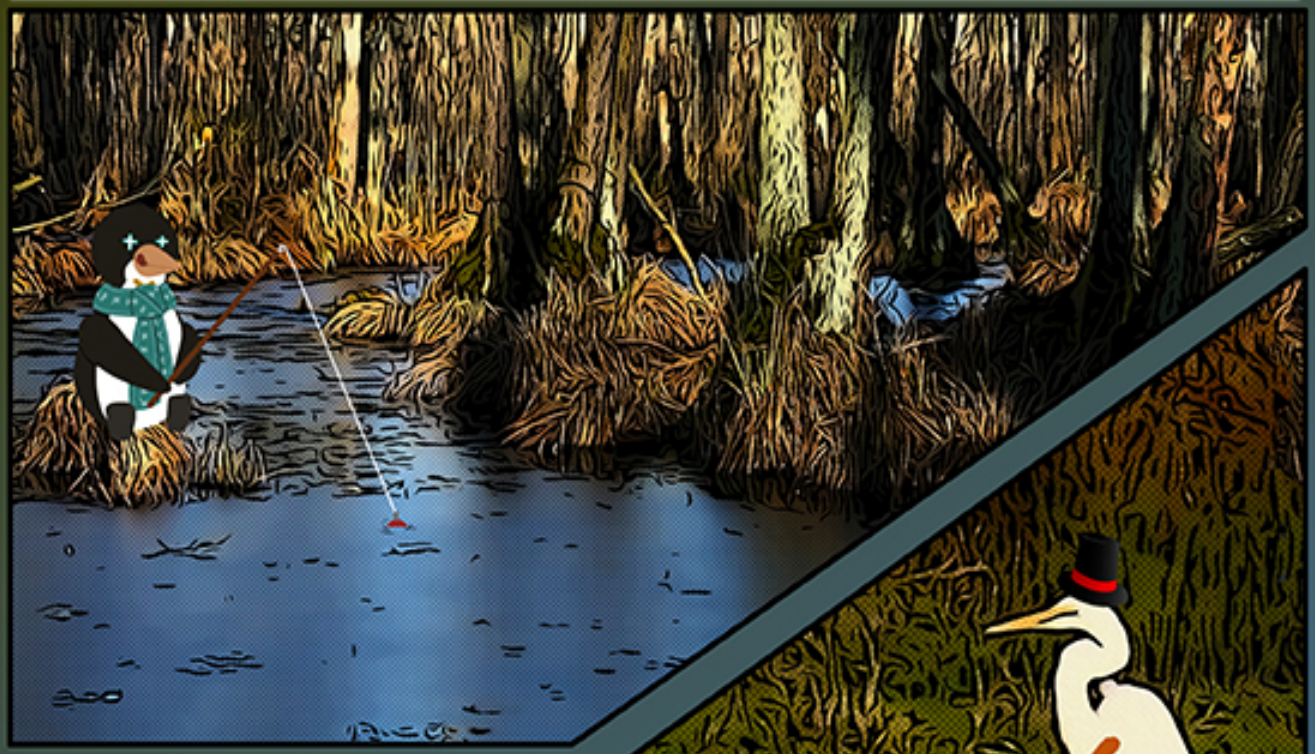
SOME EQUIPMENT WAS INSTALLED IN REMOTE AREAS OF THE TUNDRA AND SOME SENSORS WERE INSTALLED IN WIND PARKS.

THE SENSORS COLLECT CONTINUOUS RECORDS FOR AT LEAST ONE WINTER AND SUMMER SEASON EVEN IF THERE IS SNOW ON THE GROUND.

THE RECORDED DATA CAN BE EITHER DOWNLOADED THROUGH A CELL PHONE CONNECTION OR DIRECTLY TO A LAPTOP WHEN DR. SHESHUKOV AND HIS SCIENTIST FRIENDS TRAVEL TO THE RESEARCH SITES.

THEN, DR. SHESHUKOV ANALYZES THE COLLECTED DATA AND USES A COMPUTER MODEL TO HELP SCIENTISTS PREDICT FUTURE HYDROLOGICAL CONDITIONS IN THE ARCTIC WATERSHEDS.

DR. SHESHUKOV WONDERS IF THE COMPUTER MODELS WILL PREDICT MORE SWAMPS AND WETLANDS IN THE ARCTIC? HOW OFTEN WILL THE SNOWPACK BECOME SO HARD THAT REINDEER CANNOT PAW THROUGH THE SNOW FOR FOOD? HOW MIGHT WIND TURBINES IN THE WIND PARK CHANGE TEMPERATURES IN THE SOIL SURFACE AND AFFECT SNOW DISTRIBUTION?

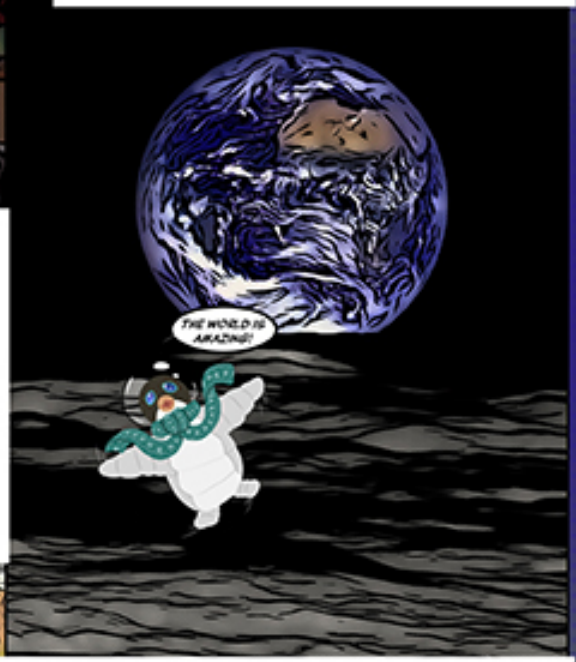


THE ANSWERS TO THESE QUESTIONS AND THE ONES ASKED BY DR. UNGAR AND DR. HESKEL DEMONSTRATE HOW INTERCONNECTED BOTH NATURAL AND HUMAN-MADE SYSTEMS ARE IN THE ARCTIC.


DR. UNGAR, DR. HESKEL, DR. SHESHUKOV, AND OTHER SCIENTISTS HOPE TO LEARN HOW THEIR RESEARCH WILL BE OF BENEFIT AND PROVIDE INFORMATION ABOUT WHAT CLIMATE CHANGE MIGHT LOOK LIKE IN THE FUTURE SO THAT THE SÁMI PEOPLE, OTHER LOCAL POPULATIONS IN FENNOSCANDIA, AND THE LARGER WORLD CAN PLAN AND PREPARE FOR A NEW CLIMATE.
I GOT PAINTED!

WHAT CAN YOU DO?

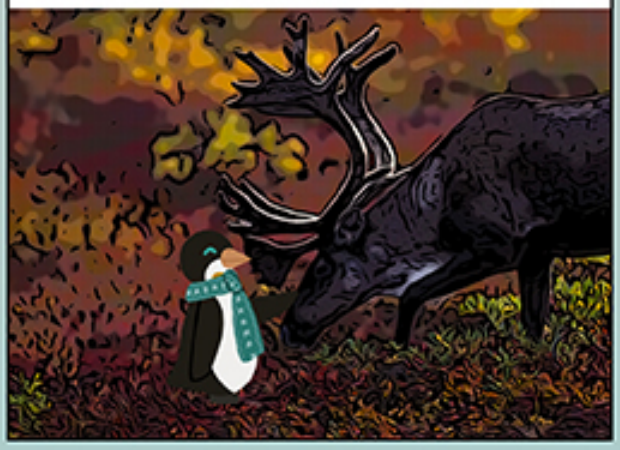
BECOME A SCIENTIST! THERE ARE MANY KINDS OF SCIENISTS STUDYING CLIMATE CHANGE.



EXPERIENCE THE INTERCONNECTEDNESS OF THE WORLD!

STAY INFORMED ABOUT HOW CLIMATE CHANGE IMPACTS YOUR OWN NEIGHBORHOOD, YOUR REGION, AND ALL OVER THE WORLD. THERE ARE MANY WAYS IN WHICH CLIMATE CHANGE SHIFTS EXOSYSTEMS AND PROCESSES ALL OVER THE WORLD. LEARNING ABOUT THESE IMPACTS CAN HELP YOU FEEL MORE CONNECTED TO YOUR LOCAL ECOSYSTEMS AND CONNECTED TO PEOPLE AND PLACES ALL OVER THE GLOBE

I HAD SO MUCH FUN IN THE ARCTIC CIRCLE!



I LEARNED SO MUCH, AND I PLAN TO SHARE MY JOURNEY!

SADLY, ALL GOOD THINGS MUST COME TO AN END.

IT'S TIME TO GO HOME. FAREWELL, ARCTIC CIRCLE!

CREDITS

POLAR STEAM FELLOWS

DR. MARY HESKEL, MACALESTER UNIVERSITY
PROF. JANICE LEDGERWOOD, CLOVIS COMMUNITY COLLEGE
DR. ALEKSEY SHESHUKOV, KANSAS STATE UNIVERSITY
DR. PETER UNGAR, UNIVERSITY OF ARKANSAS

SCIENTIST TEAM

VALERIY IVANOV
JINFENG WANG
PETER UNGAR
GERARDO CELIS
JOHN ZIKER
FLORIAN STAMMLER
OLIVER PAINE
ALEKSEY SHESHUKOV
DESHENG LIU
MARY HESKEL
MATT SPONHEIMER
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WENBO ZHOU
DOROTHEE EHRICH
OLIVIER GILG
COLIN WREN
VIOLA UKKOLA
IKRAMUL HASAN

ART DIRECTOR

GRIFFYN PULSIPHER

ARTIST TEAM

DUAA ALZAMZAMI
ADRIANA CORTES-PINTO
JAVIER DOWNS
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MACI HUERTA
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AURORA BOREALIS, MARCEL LOQUINAN
AURORA BOREALIS, HAMAR, BALTASOUND
BALD CYPRESS SWAMP
CLIMATE SCIENCE MATTERS, MELBOURNE MARCH FOR SCIENCE ON EARTH DAY
LEMMING
NORTHERN LIGHTS IN TROMSOE
OX BULLS HEAD BUTTING
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JORDAN OIL REFINERY
MAGPIE, GEESE AND WHITE EGRET, MUTTON HOLD WETLANDS, NORMANTON
PERMAFROST THAW GRADIENT AT STORDALEN MIRE
THE PINK MOMENT ON CHIEF PEAK FROM OJAI MEADOWS PRESERVE
A SWAMP IN POLAND
THUNDER, KHULNA
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ICE PATROL VESSEL, ANTARCTIC

PUBLIC DOMAIN

MALE MOOSE RESTING IN A FIELD DURING A RAINSHOWER
A MOUNTAIN OF DAMAGED OIL BARRELS
NASA EARTH AMERICA 2002
NASA EARTHRISE OVER COMPTON CRATER
OVIOS MOSCHATUS
RESEARCHERS IN A LABORATORY

EDUCATION AND RESEARCH INSTITUTIONS

U.S. National Science Foundation
WHERE DISCOVERIES BEGIN

Polar STEAM
Education. Art. Science.

Oregon State University

Clovis Community College

KANSAS STATE UNIVERSITY

UNIVERSITY OF ARKANSAS

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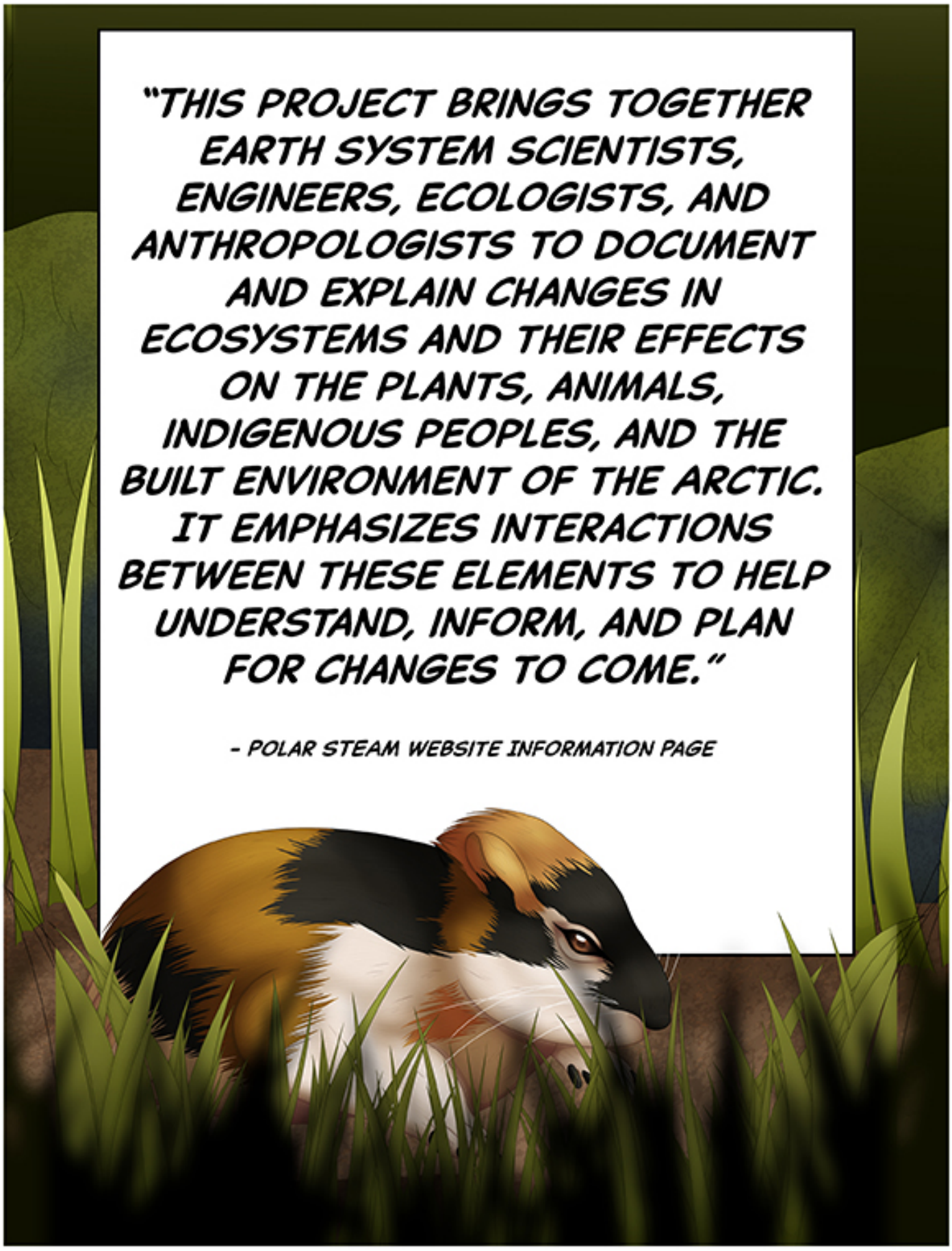
"THIS PROJECT BRINGS TOGETHER EARTH SYSTEM SCIENTISTS, ENGINEERS, ECOLOGISTS, AND ANTHROPOLOGISTS TO DOCUMENT AND EXPLAIN CHANGES IN ECOSYSTEMS AND THEIR EFFECTS ON THE PLANTS, ANIMALS, INDIGENOUS PEOPLES, AND THE BUILT ENVIRONMENT OF THE ARCTIC. IT EMPHASIZES INTERACTIONS BETWEEN THESE ELEMENTS TO HELP UNDERSTAND, INFORM, AND PLAN FOR CHANGES TO COME."
- POLAR STEAM WEBSITE INFORMATION PAGE