

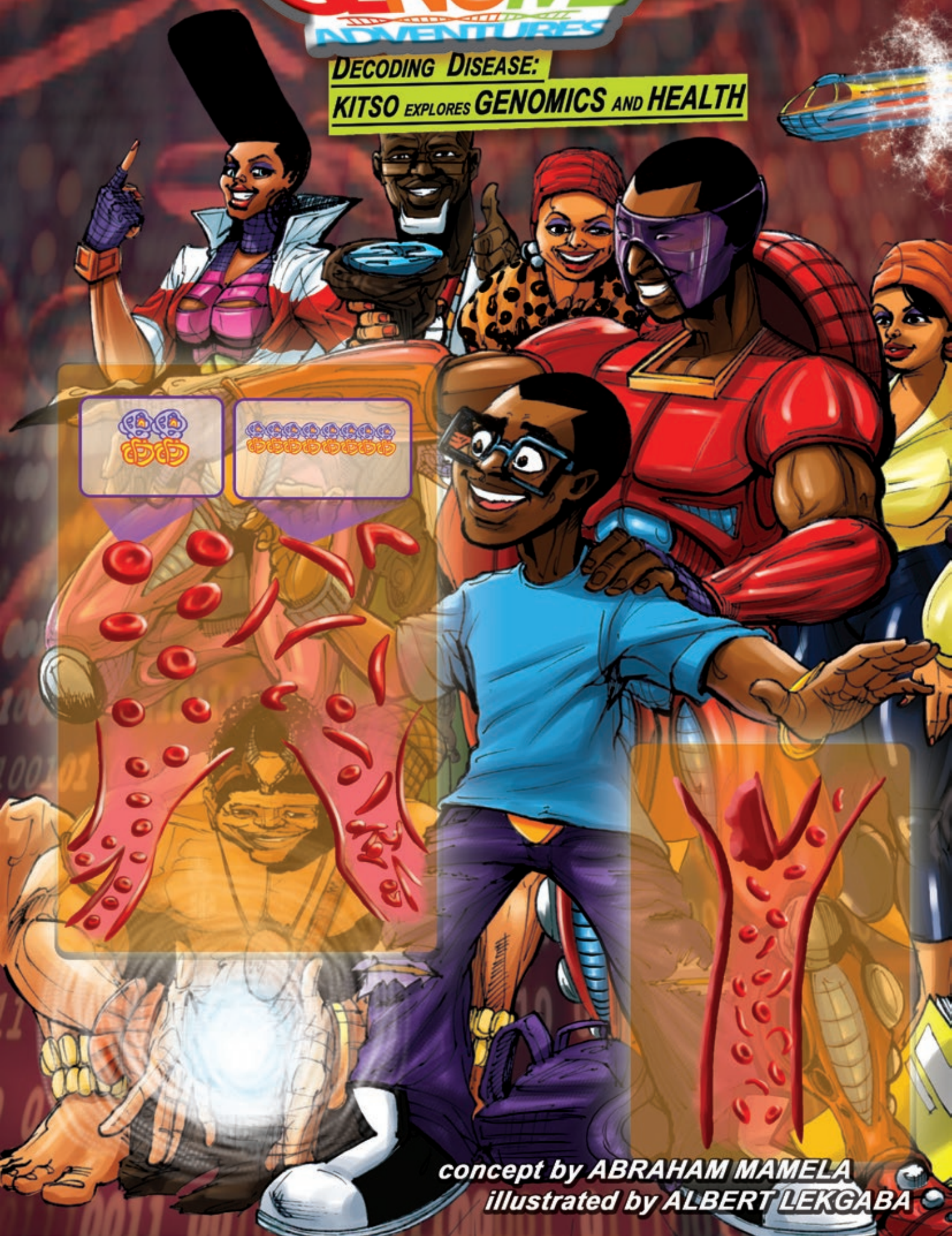
BOOK 3

GENOME

ADVENTURES

DECODING DISEASE:

KITSO EXPLORES GENOMICS AND HEALTH



concept by ABRAHAM MAMELA
illustrated by ALBERT LEKGABA

FOREWORD



The Ministry of Infrastructure, Science and Technology (MIST) has a mandate to provide and maintain building infrastructure, serve as a regulatory body for the use of nuclear technology and to coordinate Research, Science, Technology and Innovation. The key words science, research, technology and innovation define the core vision while consultation and collaboration with stakeholders are critical enablers of its mission. Broadly, MIST's stakeholders include artists and other players in the scientific arena.

The art industry plays a very crucial role in our society. Through art we can challenge our society's deepest assumptions, spark new ideas, inspire critical thought and vision and elicit new actions in society. Imaginations of future cities can come through the inspiration of artists. Through the use of cartoons and comics art can simplify and explain complex scientific concepts, demystify science and thus be a very powerful tool for communication. Therefore, we at MIST view art and artists as important collaborators and enablers of our vision and mission.

I am pleased to note that the Botswana-Baylor Children's Clinical Centre of Excellence (COE) is using art and comics to reach out, engage and educate the community on the complex topic of genes and how they relate to health and disease. In part fulfillment of the goals of the ongoing Collaborative African Genomics Network (CAfGEN) the COE has brought together a team of artists, cartoonists, scientists and journalists to develop a comic book series called Genome Adventures. Funded jointly by Wellcome Trust and the US National Institutes of Health, Genome Adventures is presented in four books. Those in the know will recall that in the first and second books, Kitso, the young hero of the series, with the assistance of several superheroes explored "Heredity and Genetics" and "Cracking the Code," respectively.

The current series of Genome Adventures consists of books three and four. In book three entitled "Decoding Disease" Kitso explores genes and health; and in the fourth entitled "Hope on the Horizon" he explores the intricacies of biomedical and genomics research. Through his amazing adventures Kitso travels the world, experiencing different cultures along the way as he learns about the link between health and genetics. As before, the books are presented in a pictorial and entertaining way using simple language and they can be enjoyed and understood by all. I understand the books will soon be translated into Setswana and several other African languages for greater reach. The Genome Adventures series clearly demonstrates that research and development offer great potential to solving societal problems; and further that even difficult scientific concepts can be communicated to all using comics. At MIST we salute all those involved in creating Genome Adventures. I wholeheartedly endorse this pioneering effort and urge those concerned to consider turning the books into a digie.

A stylized signature of Nonofiso E. Molefhi, written in black ink, enclosed within a hand-drawn circle.

Nonofiso E. Molefhi
Minister for Infrastructure, Science and Technology

KITSO



HI! MY NAME IS KITSO! I LIVE IN TLOKWENG WITH MY AUNT. I LOVE ADVENTURES! I WAS BORN WITH HIV, BUT THAT DOESN'T SLOW ME DOWN!

DR. MABOKO



I AM THE LEADER OF THE GENOME ADVENTURES SQUAD (NO MATTER WHAT KGOSIGADI TELLS YOU!). I HAVE AMAZING POWERS TO GO THROUGH WALLS AND TELEPORT WITH MY SCOOTER. AND THAT'S NOT ALL - I AM A MIND READER, TOO!

KGOSIGADI



I AM AN OUTSPOKEN LADY AND A TRUE LEADER OF MY PEOPLE, THE BATSWANAI. I MIGHT LOOK LIKE YOUR AVERAGE GRANDMOTHER, BUT MY WALKING STICK CONTAINS SPECIAL POWERS FROM MY ANCESTORS! WITH THESE POWERS, I CAN CONTROL THE WEATHER, DIRECT ANIMALS, AND DO OTHER AMAZING THINGS!

PHODISO

MY NAME IS PHODISO, BUT YOU CAN CALL ME "AUNTY". I ADOPTED MY SISTER'S CHILD, KITSO, AFTER SHE PASSED, BUT I LOVE KITSO THE SAME AS MY OTHER CHILDREN! WE LIVE TOGETHER IN TLOKWENG, JUST OUTSIDE GABORONE - WE MIGHT EVEN BE YOUR NEIGHBOURS!



XGAO-TCGAI

TCGAI! MY NAME IS XGAO-TCGAI (OR "XT" FOR SHORT). I'M A PROUD SAN MAN - SOME PEOPLE CALL MY PEOPLE "BUSHMEN" OR "BASARWA". I'M ALSO A SUPERHERO WITH TIME-TRAVELLING POWERS! MY NAME LITERALLY MEANS "BLADE-VISION" BECAUSE MY SIGHT IS AS SHARP AS A KNIFE AND I CAN EVEN SEE INTO THE FUTURE!



MARANYANE


JUST LIKE MY NAME, MARANYANE, I LOVE TECHNOLOGY. CHECK OUT MY BODY! PART OF IT IS A MACHINE AND THE OTHER PART IS HUMAN. I AM SUPER-SMART AND I LOVE USING THE LATEST GADGETS!



MMATLI

MY NAME IS MMATLI. I AM A RESEARCHER! I ALSO HAVE SUPERPOWERS TO SHRINK THINGS TO MICROSCOPIC SIZE, INCLUDING HUMANS! I LOVE THE AMAZING THINGS THAT SCIENCE HELPS US DISCOVER AND I WOULD LOVE TO SEE MORE YOUNG GIRLS IN BOTSWANA BECOME SCIENTISTS, JUST LIKE ME!







I'VE HAD A BLAST, BUT
I'M ALMOST OUT OF TIME!




WHOA! THAT'S A
WEIRD LOOKING
CELL! LOOKS LIKE
A BOOMERANG!



OH NO... IT
LOOKS LIKE
A SICKLE CELL!



WHAT'S THAT?




IT'S SOMETHING WE SHOULD
TALK ABOUT, BUT WE NEED
TO UN-SHRINK YOU. MMATLI,
LET'S BRING KITSO HOME.



SOUNDS GOOD.
READY, KITSO?



READY.



WOW, WHAT A THRILL! WHO
WOULD HAVE THOUGHT THERE'S
SO MUCH GOING ON INSIDE MY
BABY COUSIN?

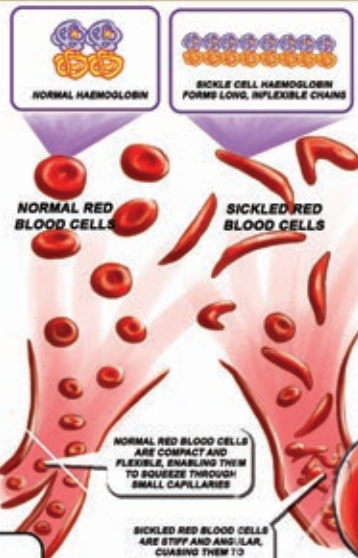


ZOOOOOOP!

BUT... WHAT WAS THAT "SICK CELL" I SPOTTED AT THE END OF MY JOURNEY?

NOT "SICK CELL," KITSO **SICKLE CELL**. DESPITE THEIR INTERESTING SHAPE, SICKLE CELLS STRUGGLE DELIVERING OXYGEN TO THE TISSUES OF THE BODY.

PEOPLE WITH SICKLE CELL DISEASE CAN HAVE BAD MUSCLE PAIN, WEAKNESS, AND OTHER SERIOUS HEALTH PROBLEMS.



SO IS TUMO GOING TO BE SICK?

HOW DID MY TUMO GET SICKLE CELL IN THE FIRST PLACE?

MUTATION? LIKE WHAT HAPPENED WHEN I DROPPED THAT PHOTOCOPY IN THE LIBRARY?

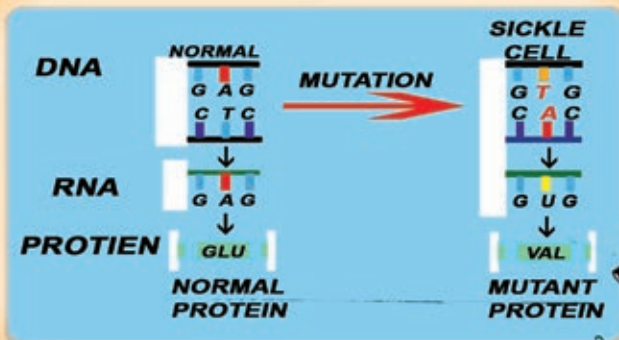
IT'S DIFFICULT TO PREDICT BASED ON ONLY ONE SIGHTING OF A SICKLE CELL.

BUT DON'T WORRY! PEOPLE WITH SICKLE CELL DISEASE OFTEN LIVE HEALTHY LIVES IF THEIR DISEASE IS MANAGED CORRECTLY.

SICKLE CELL OCCURS WHEN THERE'S A SMALL **MUTATION** IN THE GENETIC CODE.

EXACTLY. MUTATIONS CAN CAUSE DRASTIC CHANGES IN CELL SHAPE AND FUNCTION.

IN SICKLE CELL, A SINGLE SWITCH OF LETTERS FROM A TO T- RESULTS IN PROTEINS THAT STICK TOGETHER AND STRETCH THE CELL FROM ITS ROUND DONUT SHAPE TO THE BOOMERANG-SHAPED CELL YOU SAW.



SPEAKING OF BOOMERANG, HAS ANYONE SMELLED WHAT'S IN YOUR BABY COUSIN'S NAPPY? EWI

NOT ME!

EISH! I GUESS THAT LEAVES ME. COME HERE, NANA.



ARE YOU SAYING
MY BABY COUSIN
HAS A MISTAKE IN
HER GENETIC CODE?

MUTATIONS ARE SIMPLY CHANGES
IN THE GENETIC CODE. WE DON'T
CALL THEM "MISTAKES" BECAUSE
SOME MUTATIONS ACTUALLY HELP
US ADAPT TO OUR ENVIRONMENT.

SOUNDS LIKE WE'RE
EMBARKING ON THE
NEXT LEG OF OUR
JOURNEY!

ACCORDING TO MY ANCESTRY
RESEARCH, YOUR BABY COUSIN'S
ANCESTORS ARE FROM THE REGION
OF AFRICA NOW KNOWN AS ANGOLA.

SO IT'S TIME TO
SEE MUTATIONS
IN ACTION, BUDDY.

EVERYBODY STRAPPED IN?

WHAT ABOUT TUMO?


SHE'S COMING WITH US.
AFTER ALL, THIS IS HER
STORY!

SO?

ZWOOOSHI



BEM-VENDA A LUANDA.




IT'S BEM-VIN-DO, NOT VEN-DA. STOP TRYING TO SHOW OFF WITH THINGS YOU DON'T KNOW.



HUH?

WHAT HE WAS TRYING TO SAY WAS, WELCOME TO LUANDA, THE CAPITAL CITY OF ANGOLA.




EISHI IT'D BE NICE EXCEPT FOR ALL THESE MOSQUITOES!




HERE, BETTER PUT ON SOME BUG SPRAY.



THANKS! SO... WHY ARE WE HERE AGAIN?



WELL KITSO, ANGOLA HAS ONE OF THE HIGHEST RATES OF SICKLE CELL DISEASE IN THE WORLD. EVERY YEAR, AROUND 10,000 BABIES ARE BORN WITH IT.



THANKFULLY, DOCTORS AND NURSES HERE TEST FOR THE DISEASE EARLY ON, MAKING SURE THESE BABIES GET THE CARE THEY NEED.

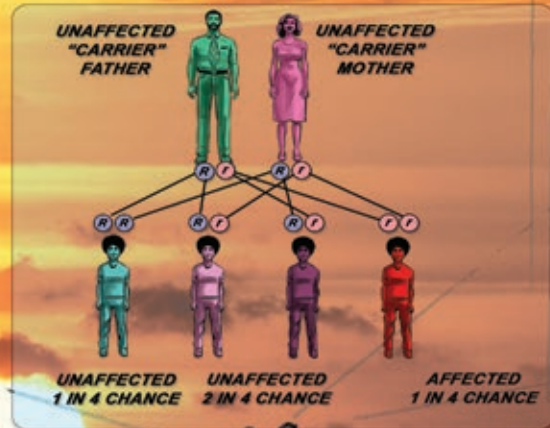


WHY IS SICKLE CELL SO MUCH MORE COMMON HERE THAN IN BOTSWANA?

IT HAS TO DO WITH THE GENES THAT YOUR ANCESTORS PASSED DOWN TO YOU!

XT'S RIGHT FOR ONCE. SICKLE CELL IS AN **AUTOSOMAL RECESSIVE** TRAIT, SO IT'S RARE, BUT STILL POSSIBLE;

POPPING UP EVERY ONCE IN WHILE IN CHILDREN WHO INHERIT THE GENE FROM BOTH THEIR MOM AND DAD.



BUT PERHAPS MORE INTERESTING IS HOW THE MUTATION GOT THERE IN THE FIRST PLACE. KITSO, DO YOU REMEMBER HOW I MENTIONED THAT MUTATIONS CAN OCCUR AS A WAY OF ADAPTING TO THE ENVIRONMENT?


YEAH. ARE YOU SAYING THAT SICKLE CELLS CAN ACTUALLY BE HELPFUL?

WELL, INHERITING TWO SICKLE CELL GENES CAN HAVE SERIOUS MEDICAL PROBLEMS. BUT FOR THOSE WHO INHERIT THE GENE FROM ONLY ONE PARENT MAY BE BETTER EQUIPPED TO AVOID ANOTHER SERIOUS SICKNESS.

REALLY? WHAT SICKNESS IS THAT?

MALARIA!


MALARIA? THE THING YOU GET FROM MOSQUITOES?

A comic book panel showing three men in conversation against a sunset background. On the left, a man with a purple mask and red suit. In the center, a man with a wide smile, hand on his forehead, wearing an orange ruffled collar. On the right, a man with glasses and a blue shirt, gesturing with his hands.


THAT'S RIGHT! THE SICKLED CELLS DON'T HAVE ENOUGH ROOM FOR THE MALARIA PARASITE TO FIT AND MULTIPLY INSIDE, SO THEY CAN'T MAKE PEOPLE SICK.

GENES CAN BE QUITE HEROIC IF THEY SET THEIR MINDS TO IT.

WOW! SO, TUMO MAY BE RESISTANT TO MALARIA? WHAT ARE THE ODDS OF THAT?

A comic book panel showing a man in a white lab coat with a stethoscope around his neck, speaking to a group. In the background, a woman in a pink and green outfit is visible.


GENETIC ADAPTATIONS OCCUR MORE FREQUENTLY THAN YOU MAY THINK, THROUGH A PROCESS CALLED NATURAL SELECTION. GENES THAT PROTECT PEOPLE FROM DISEASES ARE MORE LIKELY TO BE PASSED ON FROM GENERATION TO GENERATION.

A comic book panel showing a man in a red suit and purple mask speaking. He is gesturing with his hand.

MAYBE IN THE FUTURE, IT'LL BE OUR GENES THAT HELP FIGHT DISEASES WE AREN'T ABLE TO TREAT.

A close-up comic book panel of a man with glasses, looking thoughtful with his hand on his chin.

HMMMM...MAYBE MY GENES CAN HELP US FIGHT HIV?

A comic book panel showing a man in a white lab coat talking to a young boy in a blue shirt. They are in an outdoor setting with other people in the background.

WE HAVE REASON TO BELIEVE THEY ALREADY ARE!

YES, KITSO, YOU KNOW HOW YOU HAVE YOUR CD4 COUNT CHECKED AT THE CLINIC EVERY FEW MONTHS?

DO YOU KNOW WHAT CD4 CELLS ARE?

REALLY?

YEAH...

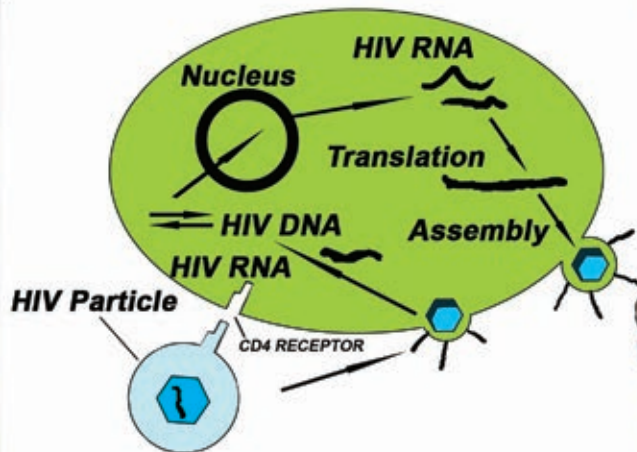
CD4 CELLS ARE THE SOLDIERS THAT HELP FIGHT INFECTION. IF I TAKE MY MEDICINE, THE BAD GUY SLEEPS, AND MY CD4 COUNT STAYS HIGH.

THAT'S RIGHT! WE CALL YOUR SOLDIERS "CD4 CELLS" BECAUSE THEY ARE COVERED IN CD4 RECEPTORS. HIGHER LEVELS OF CELLS WITH CD4 RECEPTORS MEAN THAT YOUR IMMUNE SYSTEM IS STRONG.

BUT CD4 IS ALSO LIKE THIS DOOR. IT'S THE ENTRANCE TO YOUR PROTECTOR CELLS. HIV - THE BAD GUY - ATTACKS BY GRABBING ONTO CD4 RECEPTORS AND ENTERING THE CELL, WHERE IT THEN MULTIPLIES.

NOW, WHAT IF I TOLD YOU WE COULD LOCK THE CD4 DOORWAY TO OUR PROTECTOR CELLS AND KEEP HIV OUT?

IS THAT POSSIBLE?



YES, **CCR5** IS THE LOCK ON THE CD4 DOOR. HIV USES A KEY FOR THIS LOCK TO OPEN THE CD4 DOOR, BUT IT TURNS OUT THAT SOME PEOPLE'S GENES HAVE CAUSED THEM TO PRODUCE A MUTATED CCR5 RECEPTOR, WHICH LEAVES HIV WITHOUT A WAY TO UNLOCK CD4. AND GUESS WHAT?

WHAT?

SOME OF THOSE PEOPLE ARE RESISTANT TO HIV.

YOU MEAN HIV CAN'T ENTER THE CELL?

THAT'S RIGHT. HIV NEVER EVEN MAKES IT INTO THE CELL. AND BECAUSE THEY CAN'T ENTER THE CELL, THEY CAN'T MAKE THE PERSON SICK.

WOW! I WISH EVERYBODY'S GENES WOULD CREATE MUTATED CCR5.

I AGREE. UNFORTUNATELY, MOST GENETIC MUTATIONS OCCUR OVER A LONG PERIOD OF TIME, MUCH LONGER THAN THE HIV EPIDEMIC HAS BEEN AROUND.

THEN HOW DO SOME PEOPLE ALREADY HAVE THE MUTATED CCR5?

HISTORY CAN TELL US! SOME PEOPLE BELIEVE THAT THE CCR5 MUTATION BELONGS TO AN ENTIRELY DIFFERENT ERA.

THE ERA OF THE BUBONIC PLAGUE.

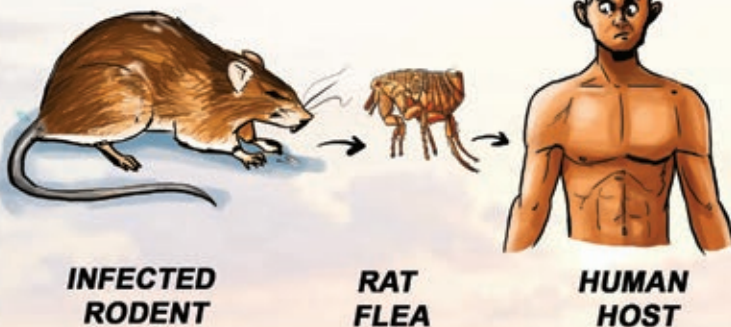
THAT DATES BACK TO THE 14TH CENTURY WHEN THE SO-CALLED "BLACK DEATH" SWEEPED THROUGH EUROPE, RESULTING IN THE DEATHS OF MILLIONS OF PEOPLE.

THE BLACK DEATH - ISN'T THAT THE DISEASE CAUSED BY RATS?

CLOSE, KITSO. THE BLACK DEATH IS CAUSED BY A BACTERIA - *YERSINIA PESTIS* - WHICH IS TRANSFERRED FROM RATS TO HUMANS VIA FLEA BITES.

SINCE MANY OF THE INDIVIDUALS THAT CARRY THE CCR5 MUTATION ARE FROM NORTHERN EUROPE,

YOU CAN'T HELP BUT WONDER IF THEIR GENES WERE TRYING TO ESCAPE THE "BLACK DEATH" AND SOMEHOW STUMBLED UPON PROTECTION AGAINST HIV.




WOW, THAT'S AMAZING, BUT...

WHAT'S WRONG, KITSO?

WELL, SICKLE CELL, HIV, BLACK DEATH... I WISH PEOPLE DIDN'T HAVE TO GET SICK.

ZWIIISHI

I UNDERSTAND. COME ON, I KNOW WHAT'LL MAKE YOU FEEL BETTER. LET'S STOP FOR LUNCH CLOSER TO HOME. THE STORY OF **GENETIC ADAPTATION** IS NOT YET FINISHED!



WELCOME TO THE GHANZI DISTRICT OF THE KALAHARI.

HAVE A SNACK!

LIKE THE PREVALENCE OF SICKLE CELL IN ANGOLA, TB AFFECTS RESIDENTS OF THE GHANZI DISTRICT AT EXTREMELY HIGH RATES.

HOW IS THAT SUPPOSED TO MAKE ME FEEL BETTER?

WELL, THERE'S GOOD NEWS, EVEN IN THE MIDST OF SICKNESS. THE FUTURE IS RICH WITH POSSIBILITY.

SCIENTISTS ARE LEARNING THAT EVEN TB MAY HAVE SPECIFIC GENES THAT COULD LEAD TO ITS CURE.



LOOKS LIKE KITSO WOULD BENEFIT FROM A GLIMPSE INTO THE FUTURE!

WHOA!!!

IN THE FUTURE, WE WILL HAVE ACCESS TO MORE KNOWLEDGE, PARTICULARLY ABOUT GENOMICS. PEOPLE WILL BE ABLE TO MANAGE ILLNESSES LIKE TB, HIV, AND SICKLE CELL A LOT BETTER.

THE GHANZI DISTRICT WILL BE A HEALTHIER PLACE.

YOU'RE RIGHT, XT. THIS DOES MAKE ME FEEL BETTER. THE FUTURE LOOKS AWESOME! I JUST WISH GHANZI WASN'T SO DRY NOW...

CAN FIX THAT! BUT FIRST WE NEED TO GO TO THE **KGOTLA**...

I'LL ALSO NEED SOME
GOURDS FILLED WITH WATER...

I HAVE SOME RIGHT HERE!

GIVE US HEAVY SHOWERS,
OPEN UP THE HEAVENS AND
POUR OUT THE RAINDROPS;
GOOD RAIN, THAT IS VERY
GENTLE, NOT LIKE SPEARS;
A WASHING OF THE EARTH;
A FEMALE, HEAVY RAIN IN
THIS TIME!

RE FE PULA E E MASHETLA;
BULA MAGODIMO O ROTHISE
MAROTHODI;PULA E E MOLEMO;
PULA E E BONOLO, E KA
TLHATSWANG LEFATSHE;RE
KOPA PULA E NAMAGADI MO
SEBAKENG SEI

AWESOME!

IF WE CONTINUE TO BE GOOD
STEWARDS OF OUR ENVIRONMENT
AND RESOURCES, THE FUTURE CAN
AND WILL BE AWESOME.

OK, TUMO IS GETTING
HEAVY NOW. I THINK
IT'S TIME TO HEAD HOME.

I THINK YOU'RE
RIGHT, KGOSIGADI.

MAMA!!!

SO... WHEN WILL THE
FUTURE BE HERE? DO
I JUST HAVE TO WAIT
FOR CURES TO BE
DISCOVERED?



THE FUTURE MAY BE CLOSER THAN YOU THINK!

IN FACT, YOU CAN HELP BRING US THERE.

REALLY? BUT I'M JUST A KID.

REMEMBER WHY WE STARTED THIS ADVENTURE? BY JOINING THE KGALAGADI HIV/TB STUDY, WHICH IS A GENOME-WIDE ASSOCIATION STUDY.

A GENOME-WIDE ASSOCIATION STUDY IS WHEN YOU TRY TO FIND THE GENES THAT DETERMINE WHY DIFFERENT PEOPLE RESPOND DIFFERENTLY TO CERTAIN DISEASES.

IN JOINING THE KGALAGADI HIV/TB STUDY, YOU'D BRING US ONE STEP CLOSER TO A HEALTHY FUTURE. MAYBE WE CAN FIGURE OUT WHY HIV AND TB BEHAVE THE WAY THEY DO. MAYBE WE CAN FIND LOCKS FOR THE DOORS—LIKE THE CCR5 MUTATION—AND PREVENT DISEASES FROM SPREADING.

A GE-WHAT?



WHAT DO YOU THINK, KITSO? HOW ARE YOU FEELING ABOUT ALL OF THIS?

ARE YOU READY TO JOIN THE STUDY, PROPELLING US INTO THE FUTURE?

AND PERHAPS, IN SO DOING, CHANGING THE COURSE OF HISTORY?

I THINK I'VE MADE MY DECISION.



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GENOME ADVENTURES

GENOME ADVENTURES IS AN INNOVATIVE WELLCOME TRUST-FUNDED COMMUNITY ENGAGEMENT INITIATIVE OF THE COLLABORATIVE AFRICAN GENOMICS NETWORK (CAFGEN). CAFGEN IS A MEMBER OF THE HUMAN HEREDITY AND HEALTH IN AFRICA CONSORTIUM (H3AFRICA) AND IS COORDINATED BY THE BOTSWANA-BAYLOR CHILDREN'S CLINICAL CENTRE OF EXCELLENCE (COE). GENOME ADVENTURES UTILIZES CAPACITY BUILDING WORKSHOPS, EDUCATIONAL COMICS, AND SOCIAL MEDIA TO ENGAGE COMMUNITY STAKEHOLDERS, MEDIA PRACTITIONERS, AND THE GENERAL PUBLIC - ESPECIALLY THE YOUTH - IN GENOMICS AND BIOMEDICAL RESEARCH. OUR GENOME ADVENTURES COMIC BOOK SERIES AIMS TO EDUCATE READERS ON THE HISTORY OF HEREDITY AND GENETICS, THE STRUCTURE AND FUNCTION OF DNA AND GENES, THE LINK BETWEEN GENOMICS AND HEALTH, AND THE PROCESS FOR ENROLLING IN A BIOMEDICAL OR GENOMICS RESEARCH STUDY, INCLUDING ETHICAL ISSUES PERTAINING TO INFORMED CONSENT, SAMPLE SHIPPING AND STORAGE, AND COMMUNITY ENGAGEMENT.

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