UNDERSTANDING NITROGEN IN OUR WORLD

THE THREE BOOKS IN THIS SERIES ARE **UNDERSTANDING PHOSPHORUS IN OUR WORLD, UNDERSTANDING POTASSIUM IN OUR WORLD,** AND **UNDERSTANDING NITROGEN IN OUR WORLD.** TEACHERS, AGRONOMISTS, PARENTS, STUDENTS AND EVERYDAY PEOPLE TOOK PART IN THE CREATION OF THESE BOOKS SO THAT THE READER WOULD DEVELOP A BETTER UNDERSTANDING FOR THE IMPORTANCE OF PLANT NUTRIENTS IN OUR LIVES.

IT WAS OUR GOAL TO PROVIDE SCIENTIFIC-BASED INFORMATION IN SUCH A WAY THAT STUDENTS, TEACHERS AND PARENTS WOULD EASILY DISCOVER HOW CLOSELY RELATED PLANT NUTRITION AND HUMAN NUTRITION ARE TO ONE ANOTHER.

UNDERSTANDING NITROGEN IN OUR WORLD

A BOOKLET DEVELOPED FOR
FOURTH THROUGH SIXTH GRADE

ILLUSTRATIONS BY
GREG CRAVENS

DID YOU KNOW THAT THERE ARE **336 MILLION KILOGRAMS** (THAT'S 336 000 000) OF NITROGEN PER ACRE **SQUASHING DOWN** ON **YOU?** ALMOST 80 PERCENT OF THE AIR AROUND YOU IS MADE OF NITROGEN. PLANTS MUST HAVE NITROGEN TO SURVIVE, BUT THEY CAN'T GET IT FROM THE MOST CONVENIENT AND ABUNDANT SOURCE...THE AIR!

SO, HERE'S WHAT WE WANT TO FIGURE OUT: HOW DOES ALL THIS GREAT NITROGEN (ALSO CALLED **N** IN THIS BOOKLET) IN THE AIR GET INTO THE PLANTS THAT NEED IT SO MUCH?

BIG WORDS

BACTERIA- SINGLE-CELLED ORGANISMS

DEFICIENCY- LACKING A NECESSARY NUTRIENT OR MINERAL

DNA & RNA- COMPOUNDS IN PLANT AND ANIMAL CELLS THAT DETERMINE GENETIC TRAITS.

GPS- GLOBAL POSITIONING SYSTEM- A NETWORK OF EARTH-ORBITING SATELLITES THAT IS DESIGNED TO HELP GROUND-BASED UNITS DETERMINE THEIR CURRENT LOCATION IN LONGITUDE AND LATITUDE.

INERT- NON-INTERACTIVE.

NITROGEN FIXATION- THE PROCESS OF CHANGING ATMOSPHERIC NITROGEN TO A FORM PLANTS CAN USE.

NUTRIENT- FOOD FOR PLANTS OR ANIMALS.

UPTAKE- TO REMOVE DIRECTLY FROM THE SOIL

VARIABLE RATE- APPLICATION OF NUTRIENTS TO A FIELD TO FIT SPECIFIC SOIL AND PLANT NEEDS.

WHAT IS NITROGEN? AN ELEMENT THAT NATURALLY EXISTS IN AIR AND IS NEEDED BY PLANTS TO PRODUCE, AMONG OTHER SUBSTANCES, PROTEINS, CHLOROPHYLL, DNA AND RNA.

80% OF THE AIR WE BREATHE IS **N**.

EACH ACRE OF THE EARTH'S SURFACE IS COVERED BY ABOUT 37,000 TONS OF **N**... BUT THIS FORM OF **N** IS AN INERT GAS.

THERE ARE MANY KINDS OF NITROGEN COMPOUNDS: MOST OF THE **N** IN THE SOIL IS TIED UP IN ORGANIC MATTER. SOIL ORGANIC MATTER COMES FROM DEAD AND DECAYED PLANTS AND ANIMALS. THE ORGANIC MATTER MUST BE FURTHER DECOMPOSED BY SOIL MICRO-ORGANISMS BEFORE PLANTS CAN USE ITS N. MOST OF THE **N** CROPS USE COMES FROM FERTILIZERS.

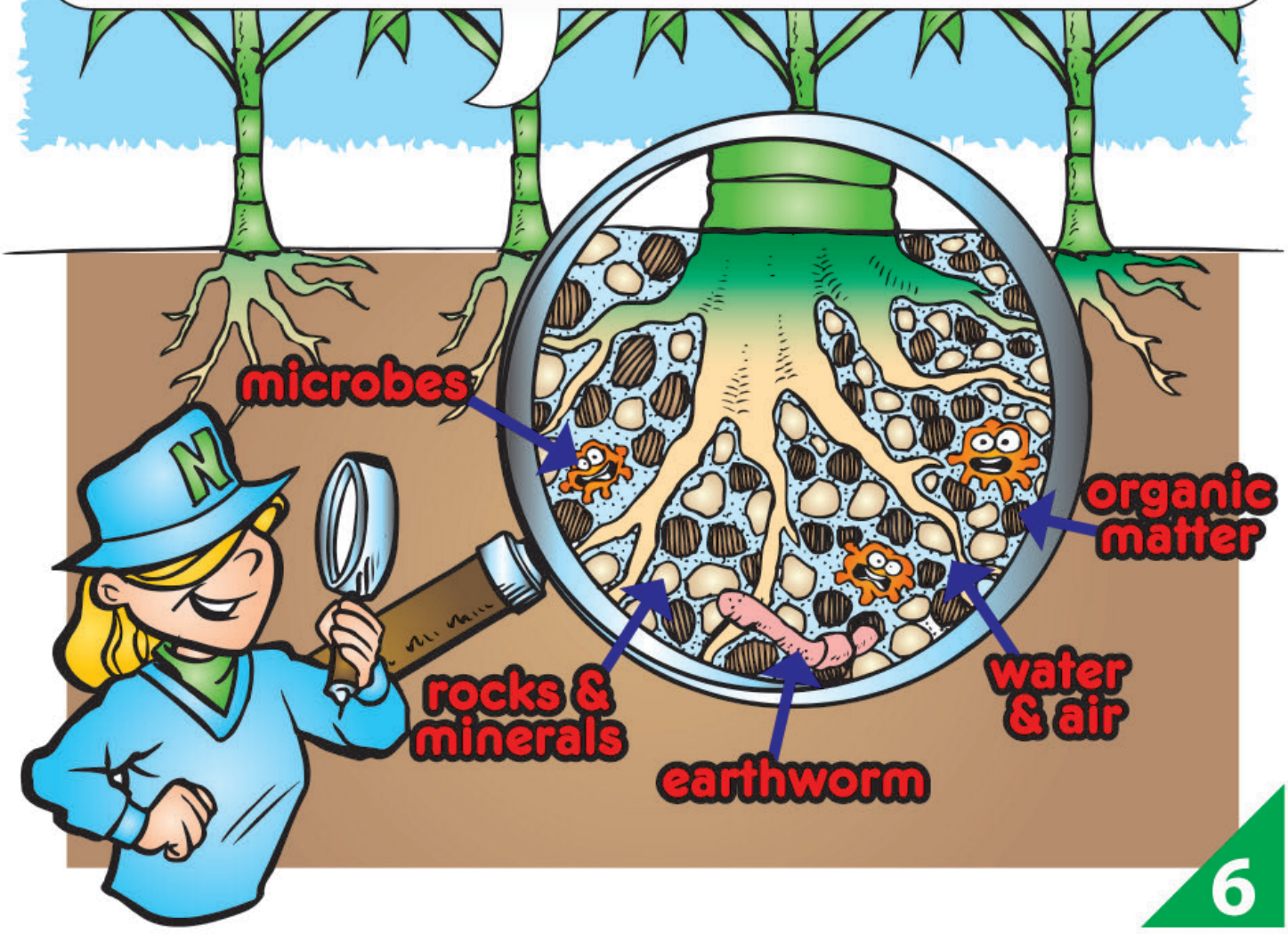
THERE ARE MANY DIFFERENT FORMS OF **N** FERTILIZER.

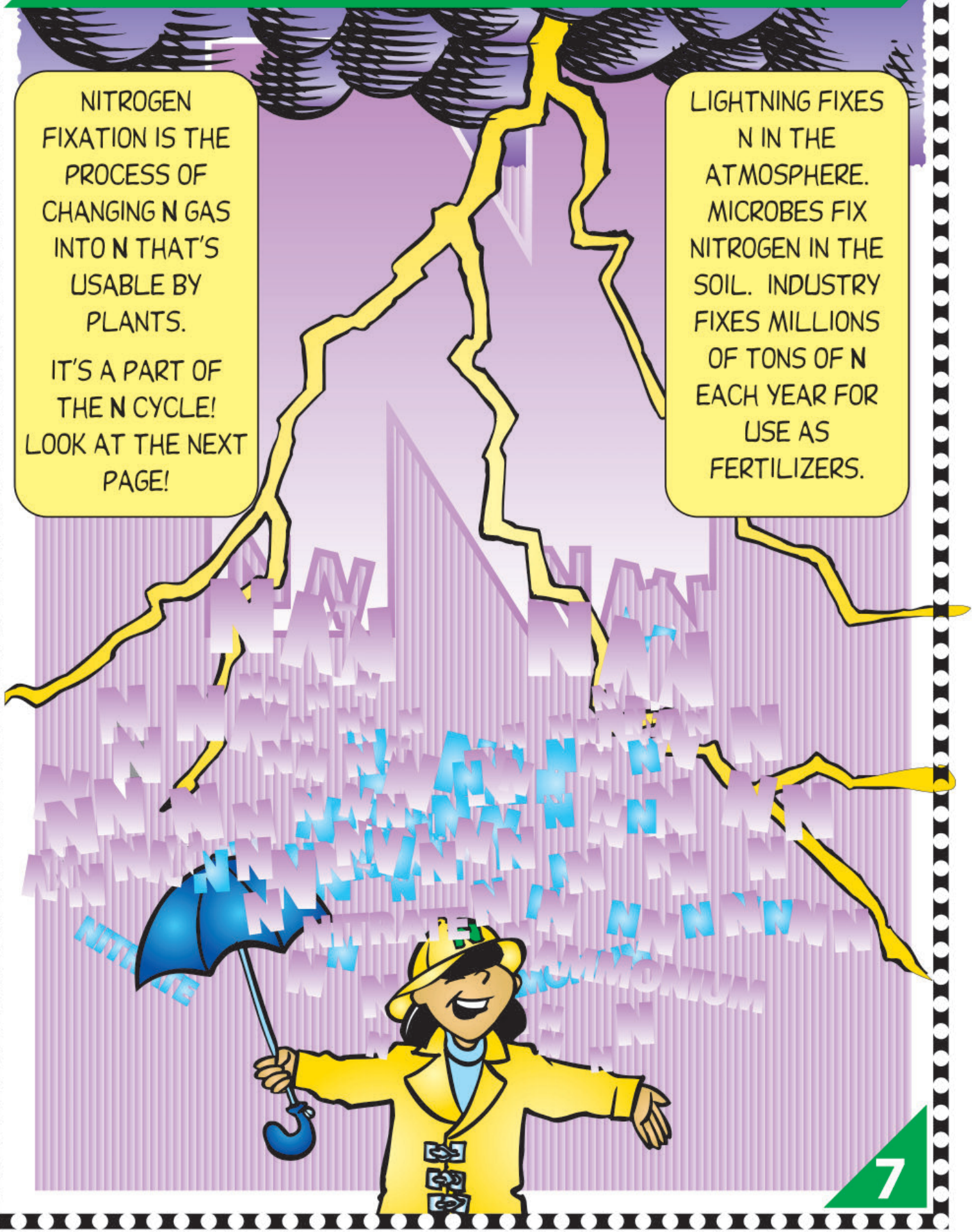

NITROGEN IS IN ALL LIVING CELLS. ALL OF THEM: PLANT, ANIMAL AND HUMAN. WE ALL NEED NITROGEN.
IN FACT, WITHOUT NITROGEN, LIFE WOULDN'T EXIST. NITROGEN IS A PART OF ALL PROTEINS, IN BOTH ANIMALS AND PLANTS. THAT MEANS IT IS VITAL TO THE HUMAN DIET. ALSO, N IS A COMPONENT OF RNA AND DNA, THE 'BLUEPRINTS' WHICH PASS GENETIC CHARACTERISTICS FROM ONE GENERATION TO THE NEXT.

SOIL IS A LIVING AND EVER-CHANGING ORGANISM. THERE ARE MANY DIFFERENT KINDS OF SOILS, AND THE KINDS DEPEND ON THE VARYING AMOUNTS OF AIR, PLANTS, SEEDS, TRASH, ROCKS, PEBBLES, SAND, CLAY, ANIMALS, BACTERIA, AND WATER THEY CONTAIN!

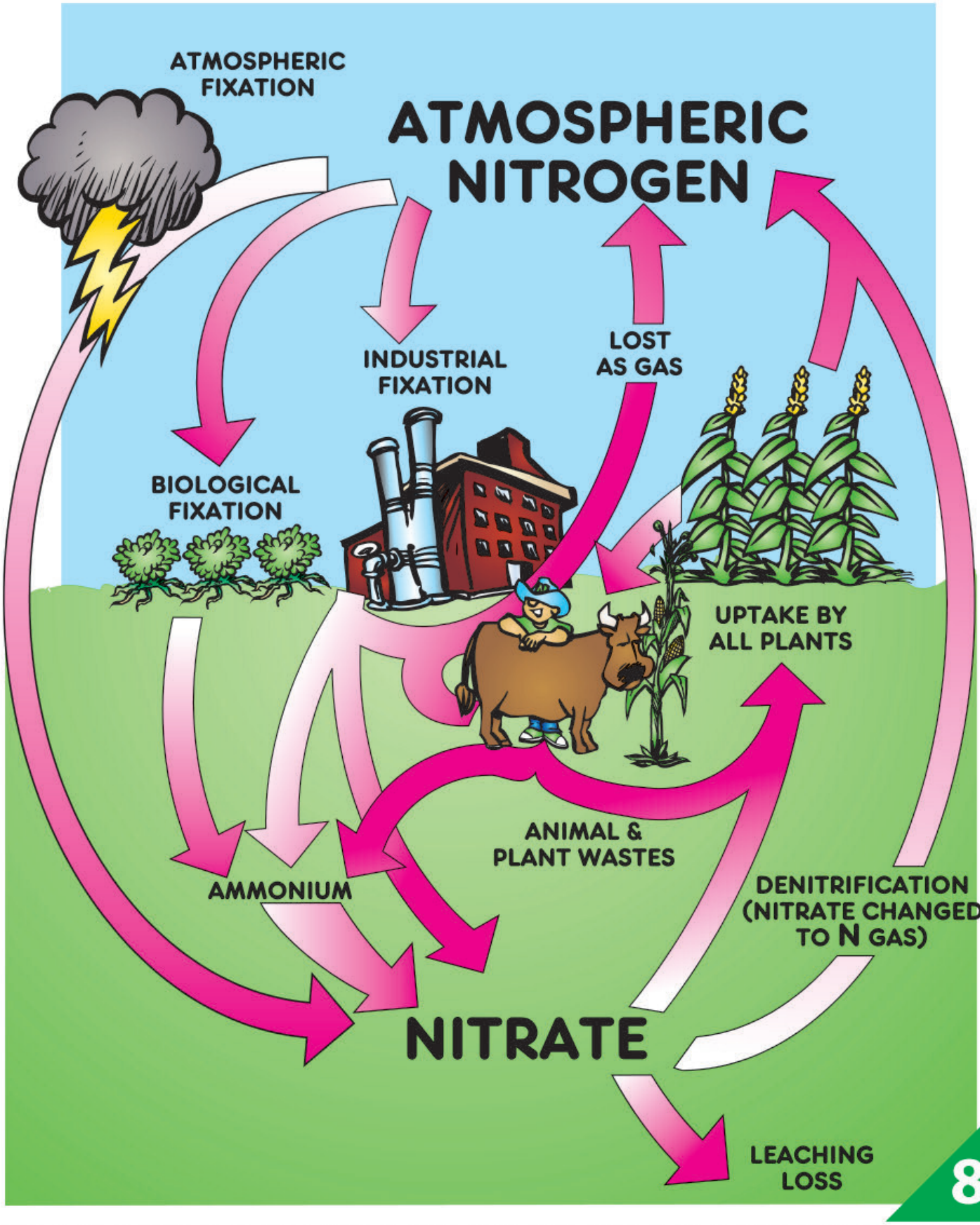
WHEN PLANT ROOTS GROW INTO THE SOIL, THEY ENCOUNTER A MIXTURE OF INTERESTING THINGS. YOU SEE, THE SOIL IS NOT JUST A SOLID MASS WE WALK AND PLAY ON. IT IS MADE UP OF ABOUT 50 PERCENT ROCKS, MINERALS AND LIVING CREATURES...AND ALSO ABOUT 50 PERCENT AIR AND WATER. PLANTS NEED WATER TO CARRY ON NORMAL FUNCTIONS, JUST AS PEOPLE DO. WATER ALSO CONTAINS THE NUTRIENTS PLANTS NEED TO GROW. AIR IN THE SOIL IS NECESSARY BECAUSE IT ALLOWS PLANT ROOTS TO BREATHE. YES! PLANTS DO BREATHE, JUST AS PEOPLE DO!

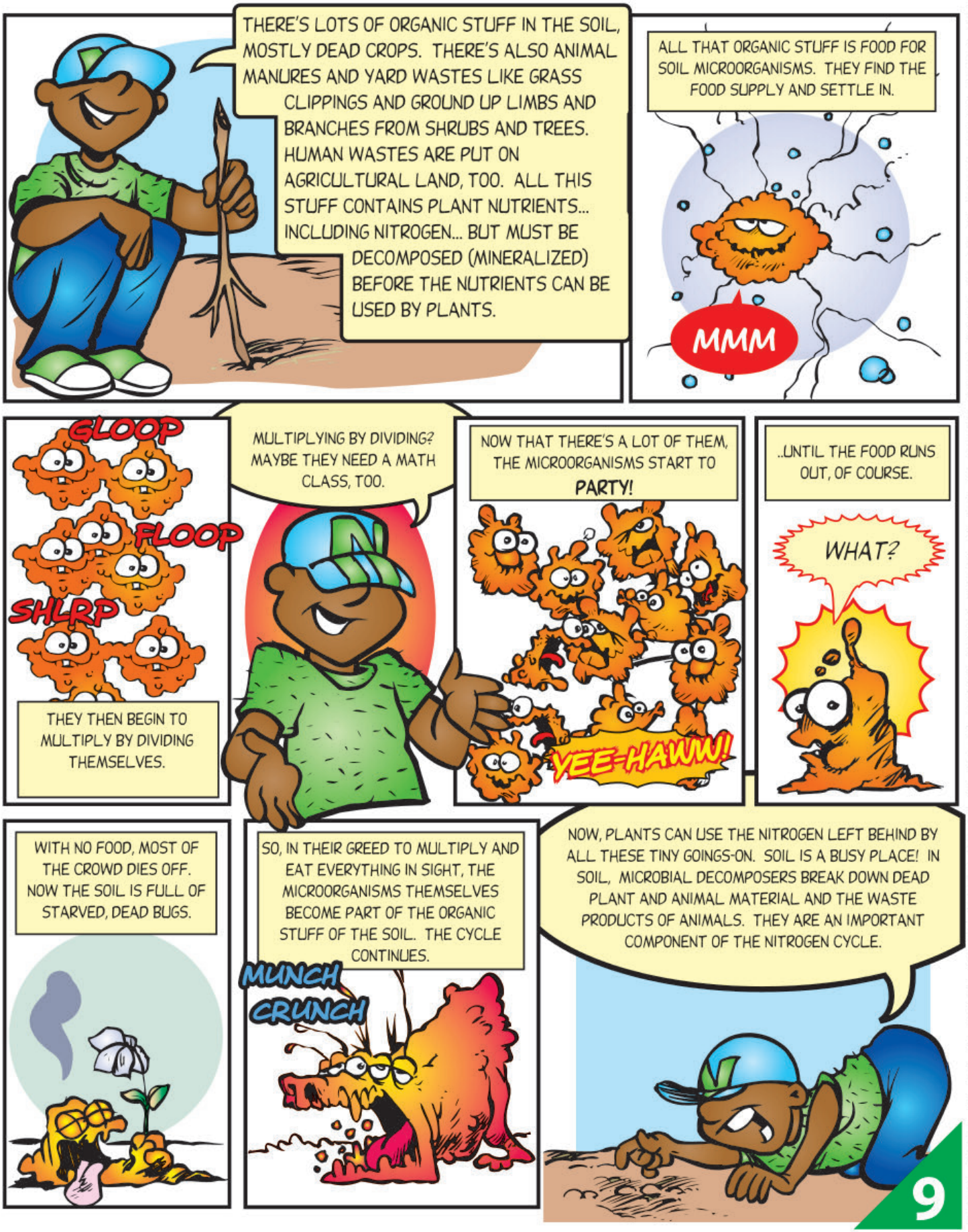
THERE ARE OTHER INTERESTING THINGS IN SOILS, TOO. EARTHWORMS, WHICH HELP TO KEEP THE SOIL HEALTHY, AND BUGS...BIG AND LITTLE. SOME OF THE CREATURES ARE TOO SMALL TO BE SEEN, BUT THEY ARE SOMETIMES VERY IMPORTANT TO PLANT HEALTH AS YOU WILL LEARN A BIT LATER.




NITROGEN FIXATION IS THE PROCESS OF CHANGING N GAS INTO N THAT'S USABLE BY PLANTS.
IT'S A PART OF THE N CYCLE! LOOK AT THE NEXT PAGE!
LIGHTNING FIXES N IN THE ATMOSPHERE. MICROBES FIX NITROGEN IN THE SOIL. INDUSTRY FIXES MILLIONS OF TONS OF N EACH YEAR FOR USE AS FERTILIZERS.

THE NITROGEN CYCLE




THERE'S LOTS OF ORGANIC STUFF IN THE SOIL, MOSTLY DEAD CROPS. THERE'S ALSO ANIMAL MANURES AND YARD WASTES LIKE GRASS CLIPPINGS AND GROUND UP LIMBS AND BRANCHES FROM SHRUBS AND TREES. HUMAN WASTES ARE PUT ON AGRICULTURAL LAND, TOO. ALL THIS STUFF CONTAINS PLANT NUTRIENTS... INCLUDING NITROGEN... BUT MUST BE DECOMPOSED (MINERALIZED) BEFORE THE NUTRIENTS CAN BE USED BY PLANTS.
ALL THAT ORGANIC STUFF IS FOOD FOR SOIL MICROORGANISMS. THEY FIND THE FOOD SUPPLY AND SETTLE IN.
MMM
GLOOP
FLOOP
SHLRP
THEY THEN BEGIN TO MULTIPLY BY DIVIDING THEMSELVES.
MULTIPLYING BY DIVIDING? MAYBE THEY NEED A MATH CLASS, TOO.
NOW THAT THERE'S A LOT OF THEM, THE MICROORGANISMS START TO PARTY!
YEE-HAWW!
..UNTIL THE FOOD RUNS OUT, OF COURSE.
WHAT?
WITH NO FOOD, MOST OF THE CROWD DIES OFF. NOW THE SOIL IS FULL OF STARVED, DEAD BUGS.
SO, IN THEIR GREED TO MULTIPLY AND EAT EVERYTHING IN SIGHT, THE MICROORGANISMS THEMSELVES BECOME PART OF THE ORGANIC STUFF OF THE SOIL. THE CYCLE CONTINUES.
MUNCH
CRUNCH
NOW, PLANTS CAN USE THE NITROGEN LEFT BEHIND BY ALL THESE TINY GOINGS-ON. SOIL IS A BUSY PLACE! IN SOIL, MICROBIAL DECOMPOSERS BREAK DOWN DEAD PLANT AND ANIMAL MATERIAL AND THE WASTE PRODUCTS OF ANIMALS. THEY ARE AN IMPORTANT COMPONENT OF THE NITROGEN CYCLE.

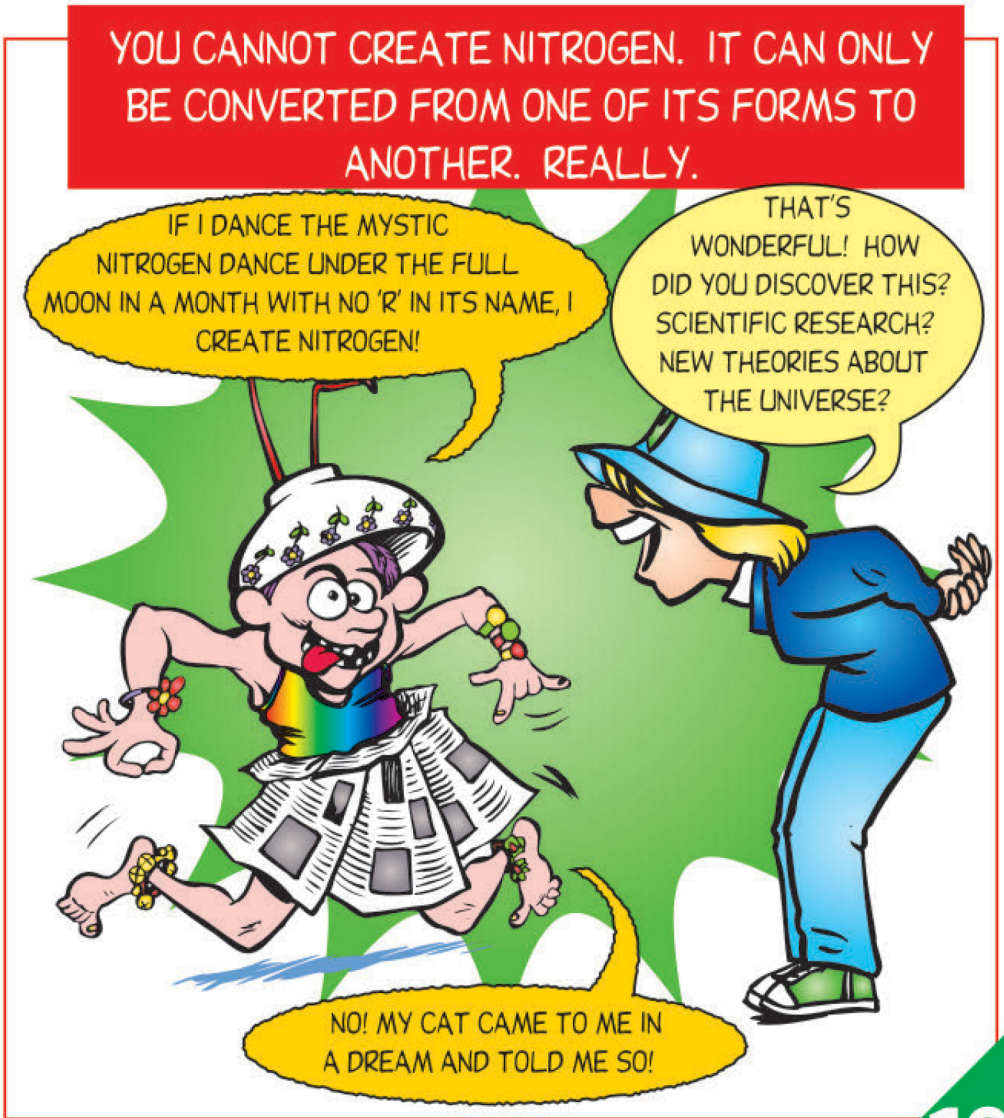
YOU ALREADY KNOW THAT THERE ARE MILLIONS OF KILOGRAMS OF NITROGEN ABOVE EVERY ACRE OF LAND IN THE WORLD. PLANTS CAN'T USE THAT NITROGEN, HOWEVER, UNLESS IT IS CHANGED TO ANOTHER FORM.

YOU FOUND OUT THAT NITROGEN IS A PART OF EVERY LIVING CELL...THAT NEITHER PLANTS NOR PEOPLE CAN LIVE WITHOUT IT. IT IS IMPORTANT IN PHOTOSYNTHESIS, IN BUILDING PROTEINS...EVEN IN DETERMINING WHAT YOUR CHILDREN AND GRANDCHILDREN WILL LOOK LIKE.

YOU PROBABLY DIDN'T KNOW BEFORE YOU READ THIS BOOKLET THAT THE SOIL IS ALIVE AND CONTAINS ALL KINDS OF STUFF...ANIMALS, MINERALS, VEGETABLES AND WASTES HUMANS THROW AWAY. SOIL IS MADE UP OF ORGANISMS, LIVING IN THE SOIL. THEY HELP TO MAKE SOIL HEALTHY AND ARE IMPORTANT TO PLANTS GROWING IN THE SOIL.

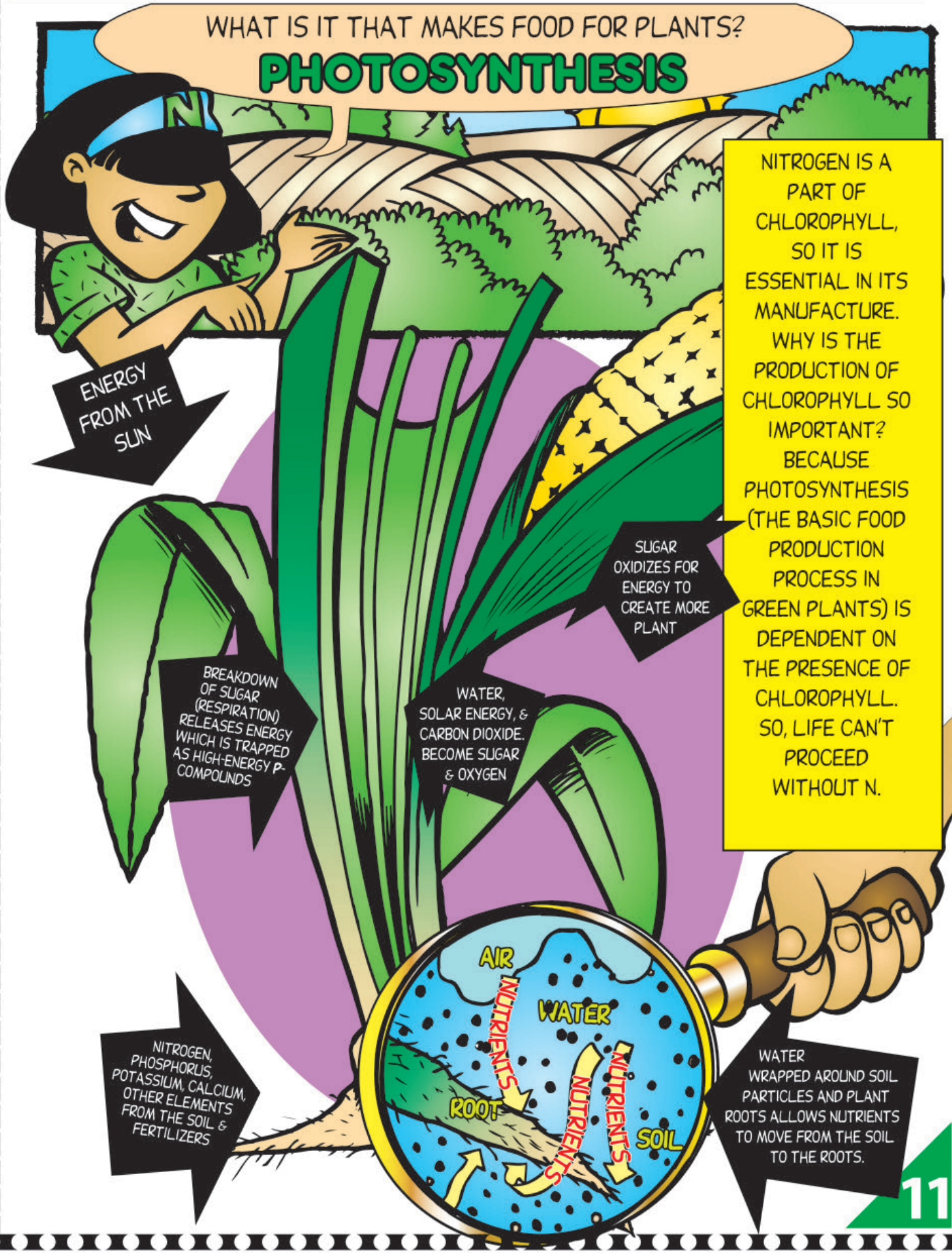
ON PAGE 6 WE SHOWED YOU THE NITROGEN CYCLE...HOW NITROGEN IS CONVERTED TO USABLE FORMS FOR CROP PLANTS, HOW IT IS AVAILABLE TO ANIMALS IN THE PLANTS THEY EAT, AND HOW IT IS LOST BACK INTO THE SOIL OR ATMOSPHERE. YOU LEARNED THAT THE PROCESS THAT MAKES THE NITROGEN AVAILABLE TO PLANTS IS CALLED FIXATION.

NOW, GET READY FOR SOME MORE ADVENTURES ABOUT UNDERSTANDING NITROGEN IN OUR WORLD.



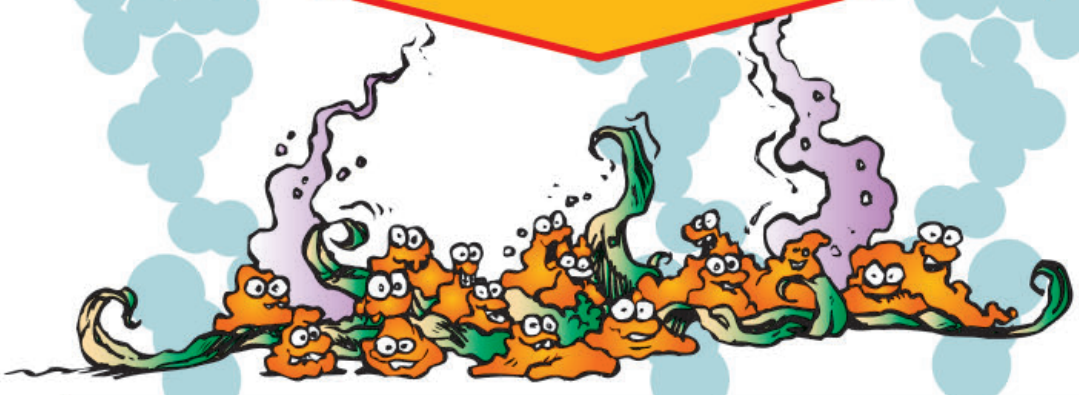
WHAT IS IT THAT MAKES FOOD FOR PLANTS?

PHOTOSYNTHESIS



NITROGEN IS A PART OF CHLOROPHYLL, SO IT IS ESSENTIAL IN ITS MANUFACTURE. WHY IS THE PRODUCTION OF CHLOROPHYLL SO IMPORTANT? BECAUSE PHOTOSYNTHESIS (THE BASIC FOOD PRODUCTION PROCESS IN GREEN PLANTS) IS DEPENDENT ON THE PRESENCE OF CHLOROPHYLL. SO, LIFE CAN'T PROCEED WITHOUT N.

WHAT DO YOU CALL IT WHEN THE REMAINS OF PLANTS ARE DECOMPOSED BY MICROORGANISMS IN THE SOIL?



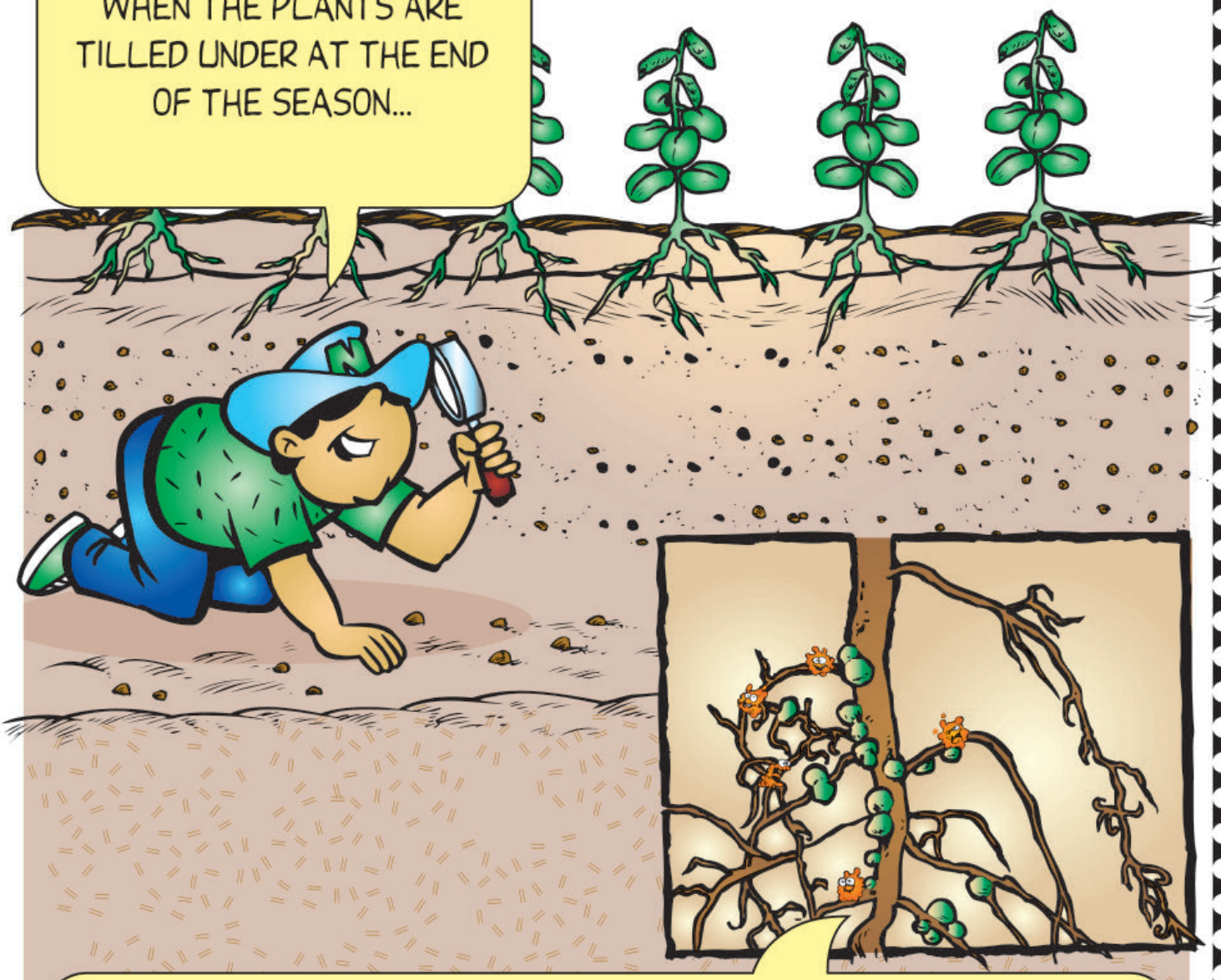
ONE OF THE PRODUCTS OF MINERALIZATION THAT PLANTS CAN USE IS AMMONIUM. OTHER MICROBES CONVERT THE AMMONIUM TO NITRATES...

...NITRATES THAT PLANTS CAN ALSO USE. THAT'S CALLED

NITRIFICATION!

LEGUMES SUCH AS BEANS, ALFALFA, AND PEAS LEAVE BEHIND SOME USABLE NITROGEN IN THE SOIL. NODULES IN THEIR ROOTS HOLD ONTO NITROGEN, THEN WHEN THE PLANTS ARE TILLED UNDER AT THE END OF THE SEASON...

LEGUME ROOTS FORM NODULES THAT HOUSE CERTAIN MICROBES THAT USE ATMOSPHERIC N AND CONVERT IT INTO A FORM THE LEGUME (HOST PLANT) CAN USE.

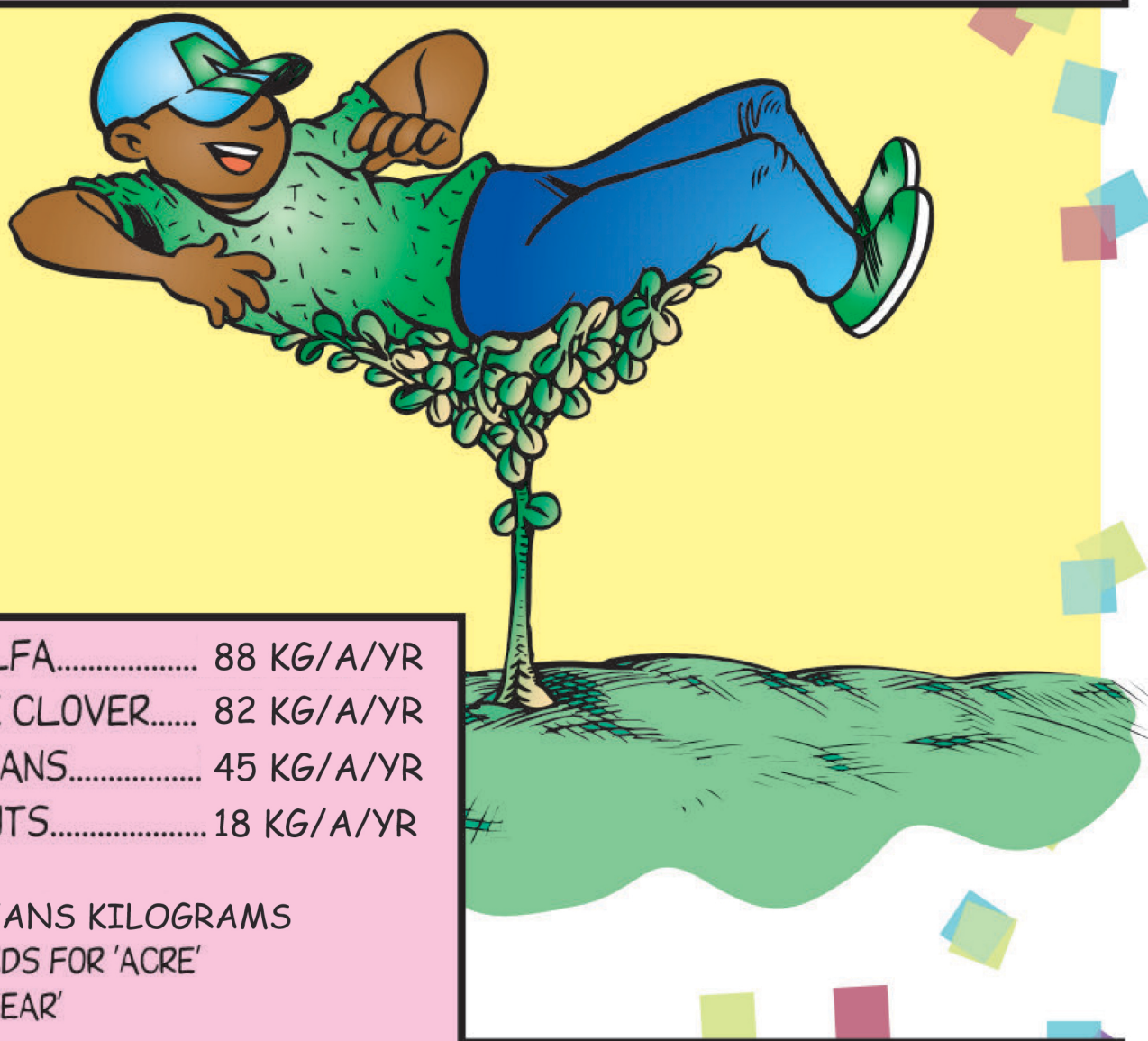


THE NODULES RELEASE THEIR STORE OF NITROGEN TO THE NEXT CROP (USUALLY ONE THAT CANNOT FIX ITS OWN NITROGEN)...WHEAT, CORN, COTTON, TOMATOES, POTATOES, LETTUCE, ETC.

REMEMBER HOW THERE'S A LOT OF NITROGEN IN THE AIR AROUND US, BUT PLANTS CAN'T JUST BREATHE IT AND USE IT THE WAY IT IS? WELL, HERE'S HOW PLANTS SOLVE THE PROBLEM:

FIXATION

FIXATION MUST OCCUR BEFORE N CAN BE USED BY PLANTS. LEGUMES, LIKE ALFALFA OR PEANUTS, ARE REALLY GOOD AT FIXATION, THOUGH NOT EQUALLY GOOD. GENERALLY, LEGUMES STORE USABLE NITROGEN IN SPECIAL NODULES ON THEIR ROOTS. THE NEXT CROP CAN TAKE ADVANTAGE OF THE NITROGEN LEFT WHEN THOSE NODULES DECOMPOSE IN THE SOIL. CLEVER, HUH? SOME LEGUME CROPS FIX MORE NITROGEN THAN OTHERS:



ALFALFA.....	88 KG/A/YR
WHITE CLOVER.....	82 KG/A/YR
SOYBEANS.....	45 KG/A/YR
PEANUTS.....	18 KG/A/YR

KG MEANS KILOGRAMS
A STANDS FOR 'ACRE'
YR IS 'YEAR'

SO, ALFALFA FIXES 88 KILOGRAMS OF NITROGEN PER ACRE, PER YEAR. ALFALFA IS A HARD WORKING PLANT, WOULDN'T YOU SAY? 88 KILOGRAMS IS A LOT OF NITROGEN!

WHO HELPS FARMERS DECIDE HOW MUCH NITROGEN TO PUT ON THEIR SOILS SO THAT CROPS ARE HEALTHY?

FARMERS NEED TO KNOW A LOT ABOUT THEIR FIELDS IN ORDER TO DETERMINE THE RIGHT AMOUNTS OF N AND OTHER NUTRIENTS TO PUT ON THEIR CROPS, BUT THERE ARE NO MAGIC ANSWERS. HERE ARE SOME OF THE THINGS FARMERS USE IN DECIDING HOW MUCH N IS IN THE SOIL:

THE AMOUNT OF USABLE N ALREADY IN THE SOIL: THIS CAN BE DETERMINED BY TAKING SAMPLES AND SENDING THEM TO A LABORATORY.

THE KIND OF SOIL THE FARMER HAS: SOME SOILS ARE A BETTER STOREHOUSE OF N AND OTHER NUTRIENTS. OTHERS NEED MORE NUTRIENTS ADDED.

THE CROP THE FARMER INTENDS TO GROW: SOME CROPS, LIKE ALFALFA AND SOYBEANS, CAN MAKE THEIR OWN N... WITH THE HELP OF SOIL MICROBES. (REMEMBER THAT FROM BEFORE?)

THE AMOUNT OF CROP THE FARMER WISHES TO GROW: THE MORE CROP, THE MORE N NEEDED.

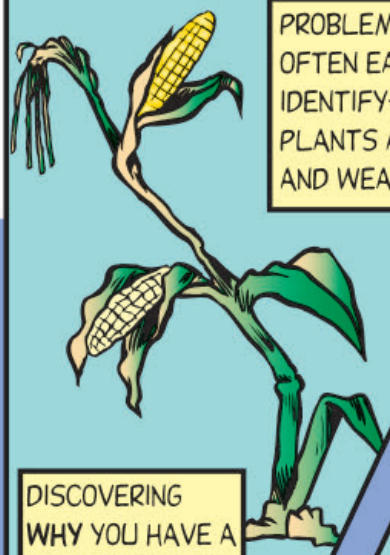
MANAGING N WISELY IS IMPORTANT TO FARMER PROFITS AND TO ENVIRONMENTAL PROTECTION.

WITH CORRECT INFORMATION, FARMERS CAN SUPPLY THE NEEDS OF ALL THE DIFFERENT CROPS GROWN ON THEIR LAND.

PROPER ANALYSIS TAKES THE GUESSWORK OUT OF NITROGEN MANAGEMENT FOR CROPS.

WHEN FARMERS ARE SUCCESSFUL, JOBS IN CITIES ARE MORE SECURE AND FOOD IS ABUNDANT FOR EVERYONE.

PROBLEMS ARE OFTEN EASY TO IDENTIFY- "MY PLANTS ARE YELLOW AND WEAK..."



DISCOVERING **WHY** YOU HAVE A PROBLEM IS THE DIFFICULTY. YOU MUST HAVE THE TOOLS AND KNOWLEDGE TO DISCOVER **"WHY".**

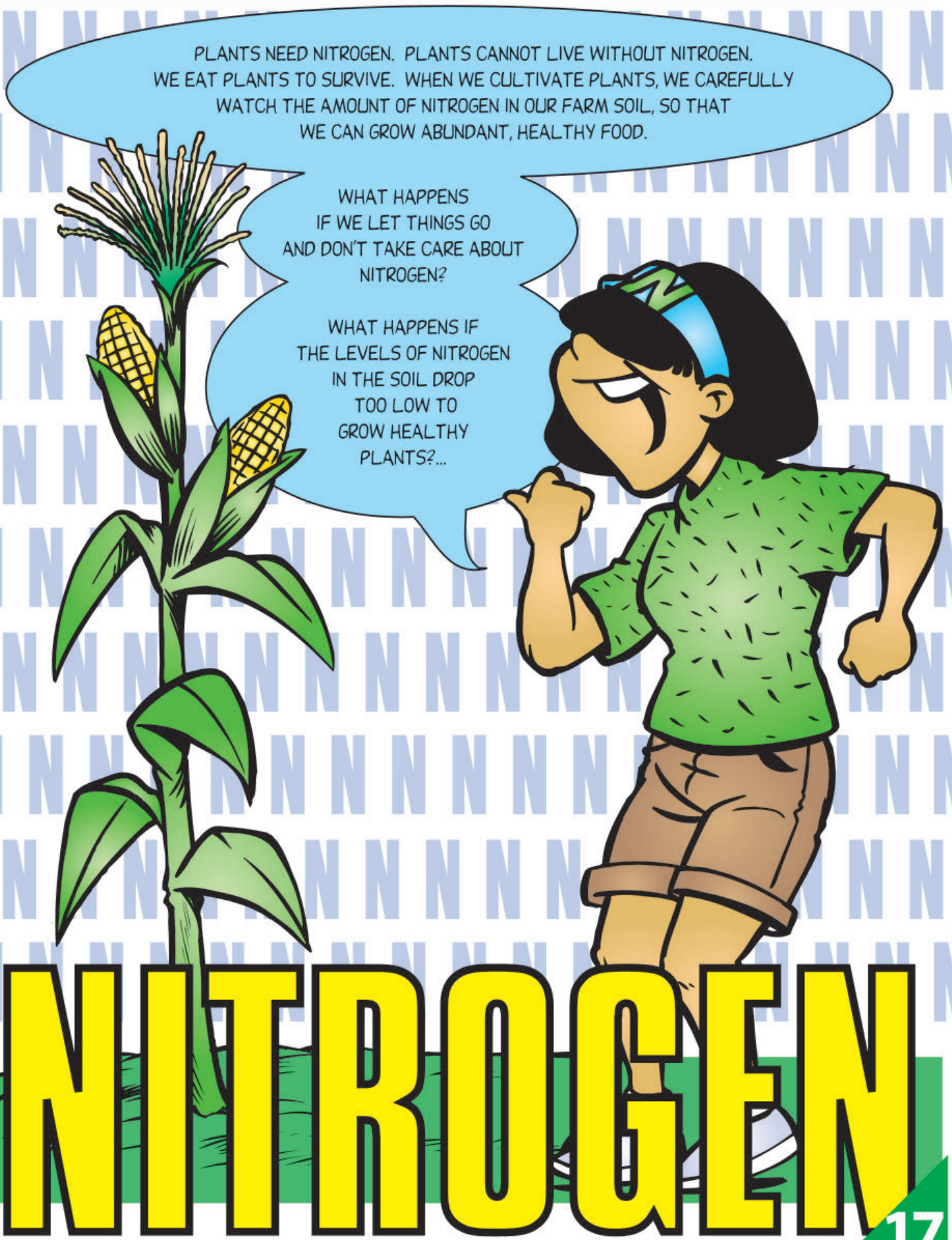
NITROGEN IS A MOBILE NUTRIENT. WATER MOVES IT AROUND. SOMETIMES IT MOVES TOO FAR DOWN IN THE SOIL FOR THE PLANT ROOTS TO REACH IT. SOIL TESTING CAN TELL FARMERS HOW MUCH N IS AVAILABLE.

IN ORDER TO SUCCESSFULLY RUN A FARM, MANAGEMENT IS A VERY IMPORTANT CONCERN. TO **IGNORE** NITROGEN LEVELS IN SOIL IS NOT GOOD MANAGEMENT.

WHEN YOU KNOW YOUR PROBLEM, WHY IT EXISTS, AND WHAT TO DO, THE ANSWER IS VERY PLAIN.

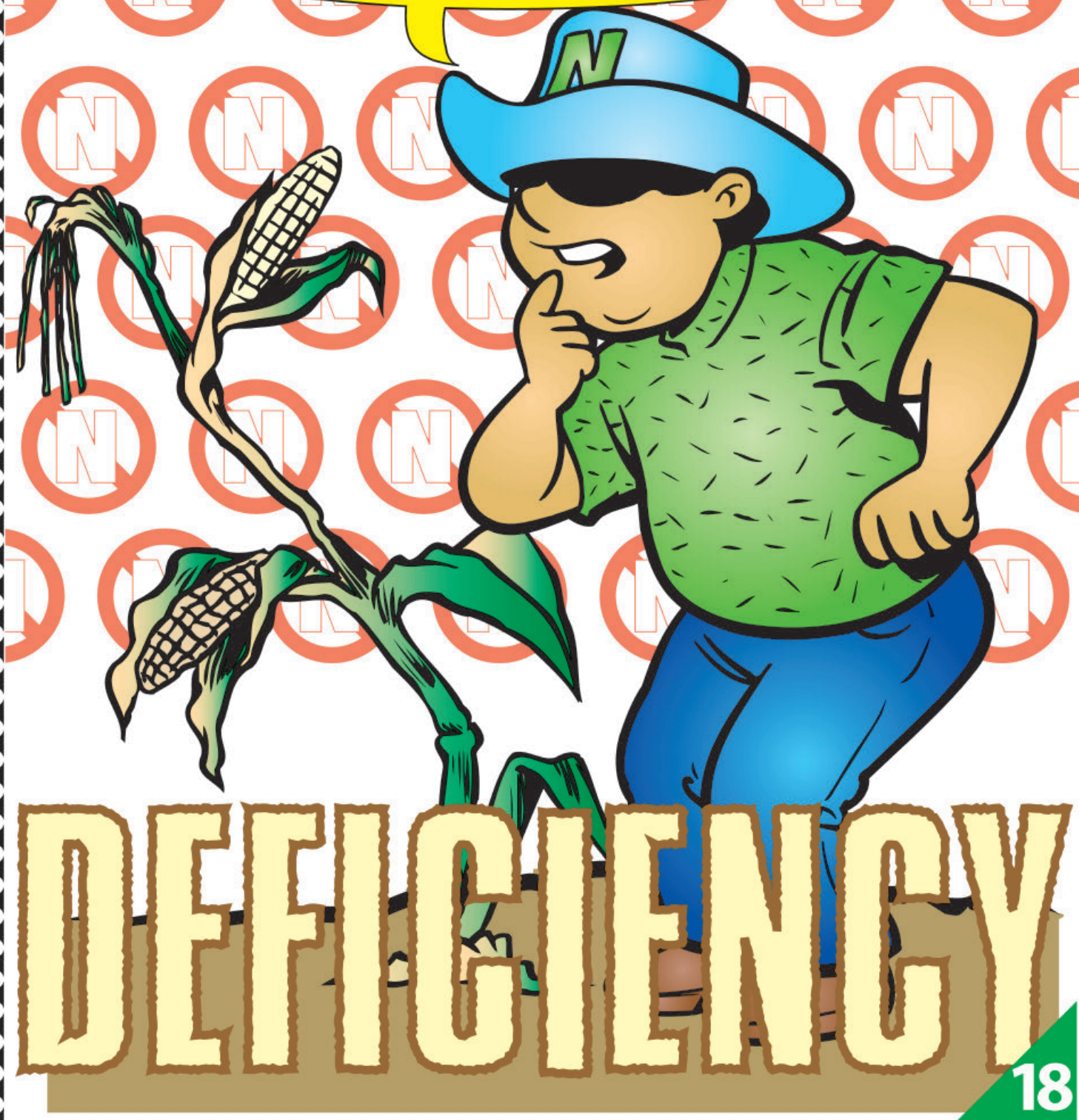
$$\begin{array}{r} 2 \\ +\,2 \\ \hline =4 \end{array}$$

TWO PLUS TWO IS NOT A MYSTERY. CROP CARE ISN'T EITHER.


PLANTS NEED NITROGEN. PLANTS CANNOT LIVE WITHOUT NITROGEN. WE EAT PLANTS TO SURVIVE. WHEN WE CULTIVATE PLANTS, WE CAREFULLY WATCH THE AMOUNT OF NITROGEN IN OUR FARM SOIL, SO THAT WE CAN GROW ABUNDANT, HEALTHY FOOD.
WHAT HAPPENS IF WE LET THINGS GO AND DON'T TAKE CARE ABOUT NITROGEN?
WHAT HAPPENS IF THE LEVELS OF NITROGEN IN THE SOIL DROP TOO LOW TO GROW HEALTHY PLANTS?...
N

NITROGEN

NITROGEN HELPS PROTECT OUR VALUABLE WATER RESOURCES AND INCREASES OUR FOOD SUPPLY. HEALTHY PLANTS, ADEQUATELY SUPPLIED WITH N, ARE BETTER ABLE TO UTILIZE AVAILABLE WATER FROM RAINFALL AND SOIL MOISTURE. A CROP WELL FED WITH N CAN PRODUCE YIELDS MANY TIMES GREATER ON THE SAME AMOUNT OF WATER THAN ONE STARVING FOR N. ALSO, A HEALTHY, FAST GROWING CROP ALLOWS MORE WATER TO SOAK INTO THE GROUND, REDUCING EROSION, INCREASING CROP YIELD POTENTIAL AND PROTECTING WATER QUALITY.



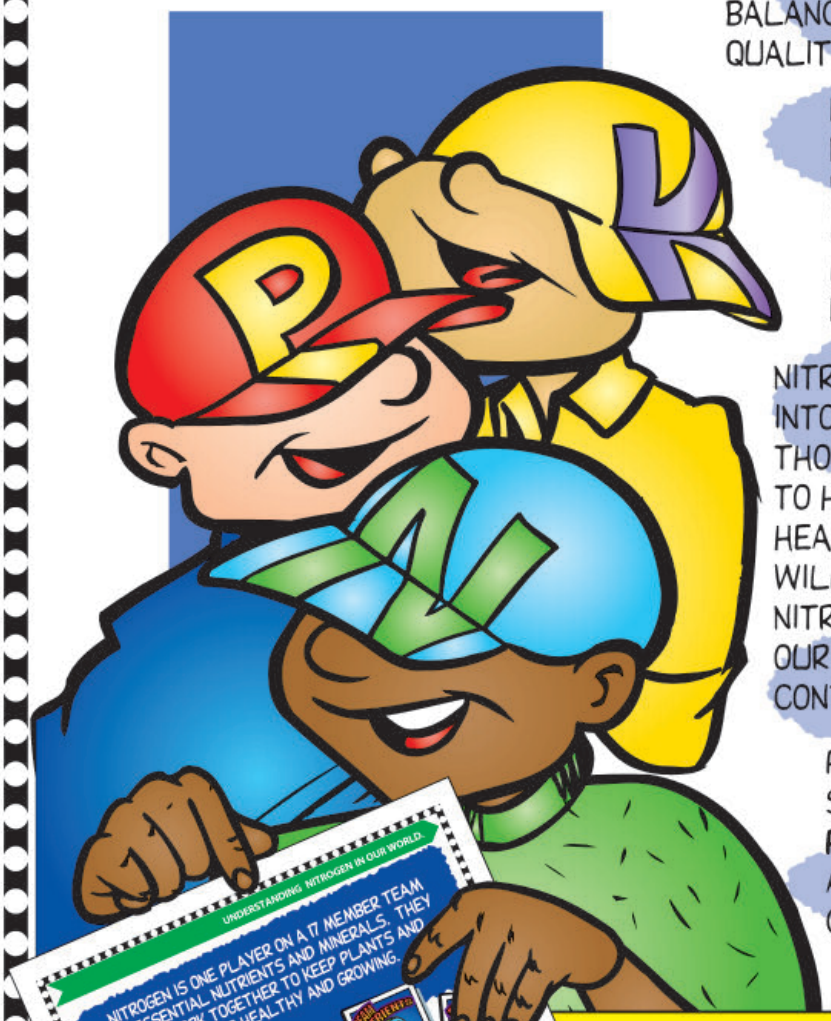
THERE IS A PICTURE OF THE PLANT NUTRIENT TEAM ON THE BACK PAGE OF THIS BOOKLET. THE PLANT'S NEED FOR THESE NUTRIENTS IS NOT UNLIKE YOUR REQUIREMENT FOR A BALANCE OF FATS, CARBOHYDRATES, AND PROTEINS IN YOUR DIET.

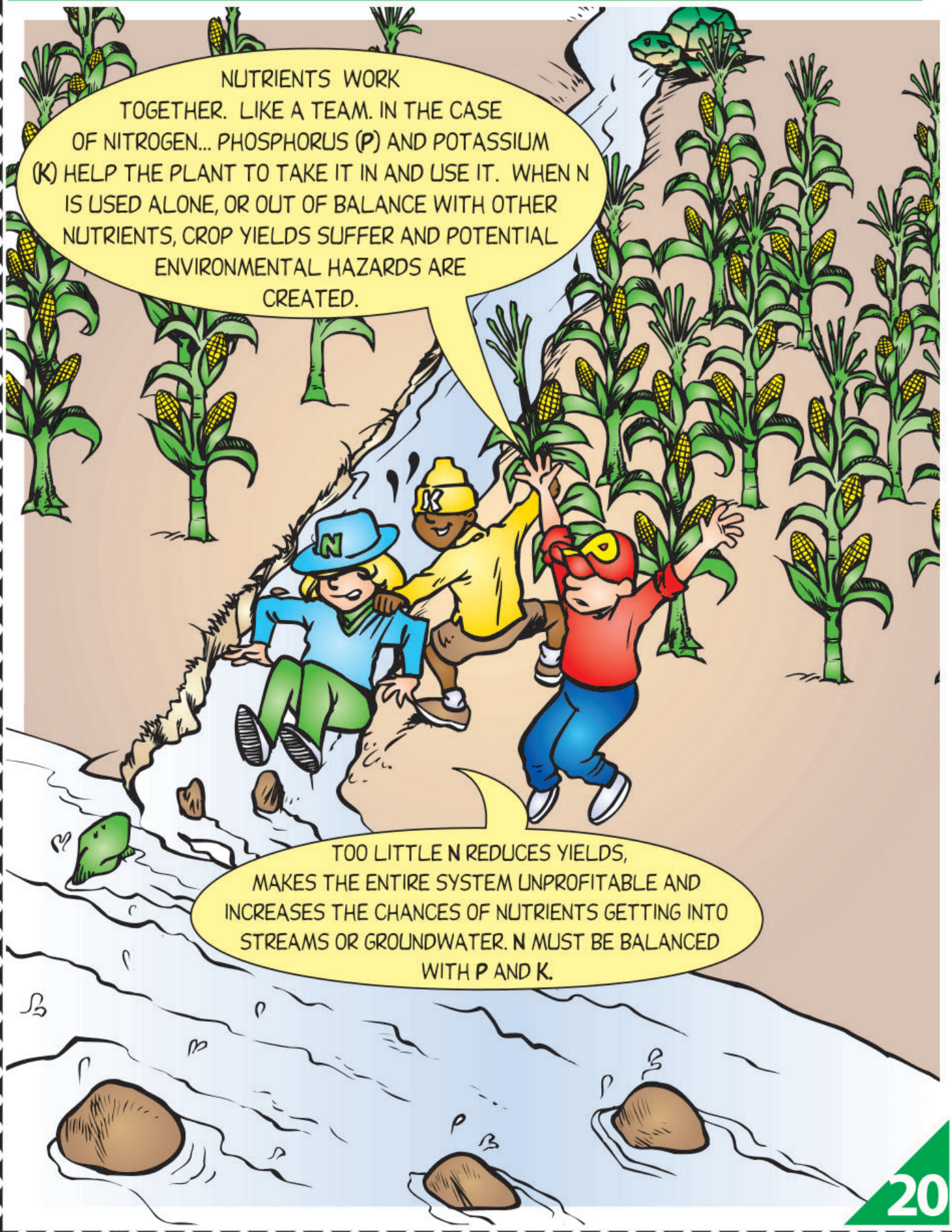
IF ONE OR MORE OF THE 17 NUTRIENTS IS MISSING OR IN SHORT SUPPLY, THE PLANT CANNOT COMPLETE ITS NORMAL LIFE CYCLE. THAT MEANS THE NUTRIENTS WHICH ARE PRESENT IN ADEQUATE AMOUNTS WOULD NOT BE USED. WASTED NUTRIENTS COST THE FARMER MONEY. THAT'S WHY IT IS SO IMPORTANT TO KEEP NUTRIENTS IN BALANCE...TO GROW HIGH YIELDS OF HIGH QUALITY, PROFITABLE CROPS.

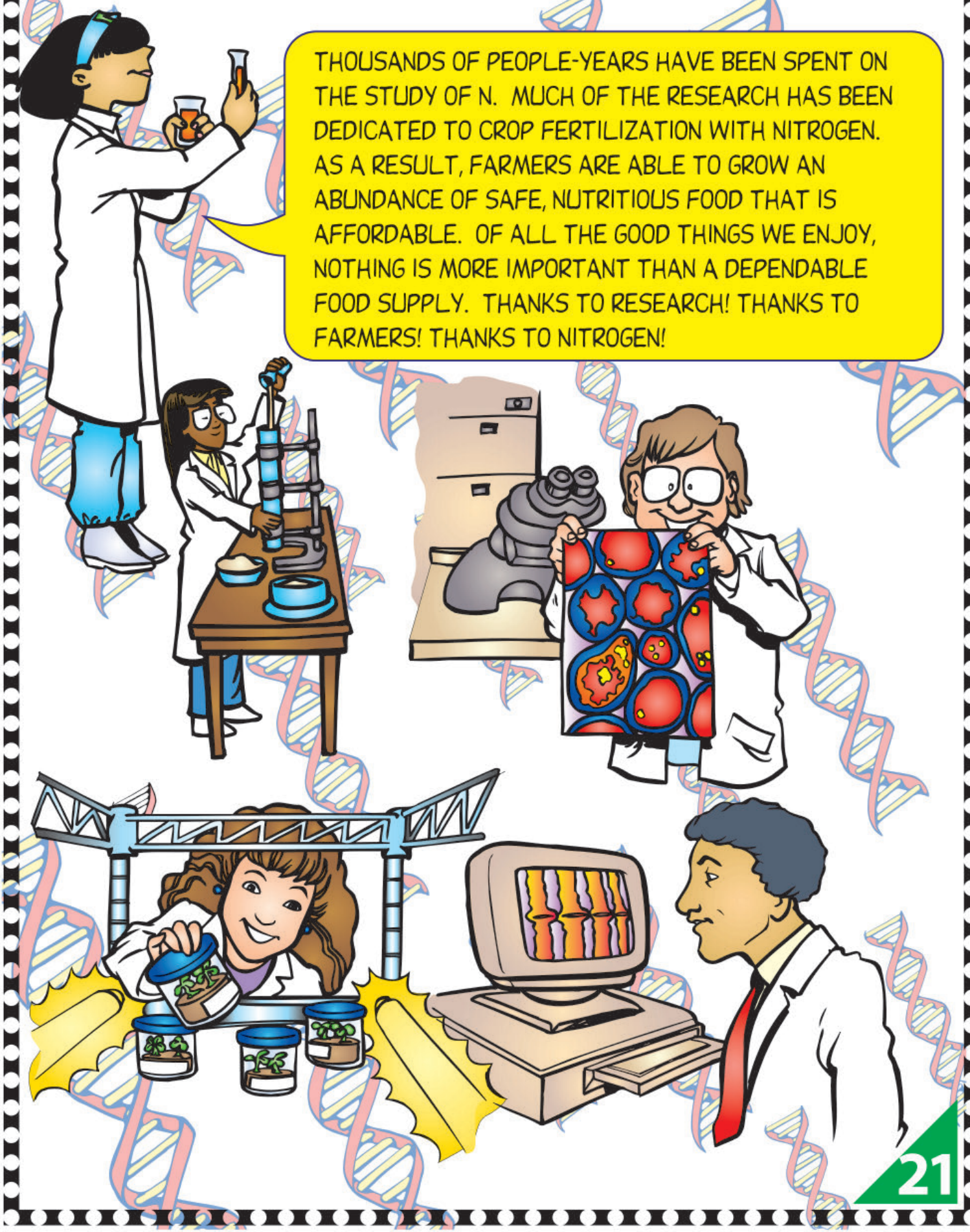
EQUALLY IMPORTANT IS THE POTENTIAL NEGATIVE IMPACT ON THE ENVIRONMENT WHEN NUTRIENT SUPPLY TO CROPS IS INADEQUATE. THE TWO NUTRIENTS MOST LIKELY TO CREATE PROBLEMS FOR THE ENVIRONMENT ARE **N** AND PHOSPHORUS (P).

NITROGEN IN THE FORM OF NITRATE CAN GET INTO OUR DRINKING WATER SUPPLY. EVEN THOUGH FERTILIZER NITROGEN IS NOT KNOWN TO HAVE NEGATIVELY AFFECTED OUR HEALTH, PROPER MANAGEMENT BY FARMERS WILL PREVENT IT FROM EVER HAPPENING. NITROGEN WILL CONTINUE TO BE CRITICAL TO OUR GOOD HEALTH THROUGH ITS CONTRIBUTION TO FOOD PRODUCTION.

PHOSPHORUS CAN AFFECT THE HEALTH OF SURFACE WATERS...LAKES AND STREAMS. IF **P** LEVELS IN WATER ARE TOO HIGH, BOTH ANIMALS AND PLANTS LIVING IN THE WATER CAN BE AFFECTED.




NUTRIENTS WORK TOGETHER. LIKE A TEAM. IN THE CASE OF NITROGEN... PHOSPHORUS (P) AND POTASSIUM (K) HELP THE PLANT TO TAKE IT IN AND USE IT. WHEN N IS USED ALONE, OR OUT OF BALANCE WITH OTHER NUTRIENTS, CROP YIELDS SUFFER AND POTENTIAL ENVIRONMENTAL HAZARDS ARE CREATED.
N
K
P
TOO LITTLE N REDUCES YIELDS, MAKES THE ENTIRE SYSTEM UNPROFITABLE AND INCREASES THE CHANCES OF NUTRIENTS GETTING INTO STREAMS OR GROUNDWATER. N MUST BE BALANCED WITH P AND K.


THOUSANDS OF PEOPLE-YEARS HAVE BEEN SPENT ON THE STUDY OF N. MUCH OF THE RESEARCH HAS BEEN DEDICATED TO CROP FERTILIZATION WITH NITROGEN. AS A RESULT, FARMERS ARE ABLE TO GROW AN ABUNDANCE OF SAFE, NUTRITIOUS FOOD THAT IS AFFORDABLE. OF ALL THE GOOD THINGS WE ENJOY, NOTHING IS MORE IMPORTANT THAN A DEPENDABLE FOOD SUPPLY. THANKS TO RESEARCH! THANKS TO FARMERS! THANKS TO NITROGEN!

IF YOU DON'T FEEL PERSONALLY CONCERNED ABOUT THE HEALTH OF CROPS YET, TRY THIS ONE ON FOR SIZE: YOU'RE HEALTHY...

BECAUSE YOU'VE EATEN FOOD THAT WAS HEALTHY. THE FOOD YOU ATE WAS HEALTHY BECAUSE...

THE FARMER GROWING THE FOOD WAS CAREFUL TO MANAGE NUTRIENT LEVELS IN HIS SOIL AND CROPS.

REMEMBER THAT IT DOESN'T HAVE TO BE THIS WAY. IT'S EASY TO GROW POOR CROPS WITH NO ATTENTION TO THE SOIL OR ENVIRONMENT, BUT IS THAT WISE? NO. IT PUTS US AND THE GENERATIONS TO COME AT A DIS-ADVANTAGE.

NITROGEN IS ONE PLAYER ON A 17 MEMBER TEAM OF ESSENTIAL NUTRIENTS AND MINERALS. THEY ALL WORK TOGETHER TO KEEP PLANTS AND ANIMALS HEALTHY AND GROWING.

UNDERSTANDING NITROGEN IN OUR WORLD

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