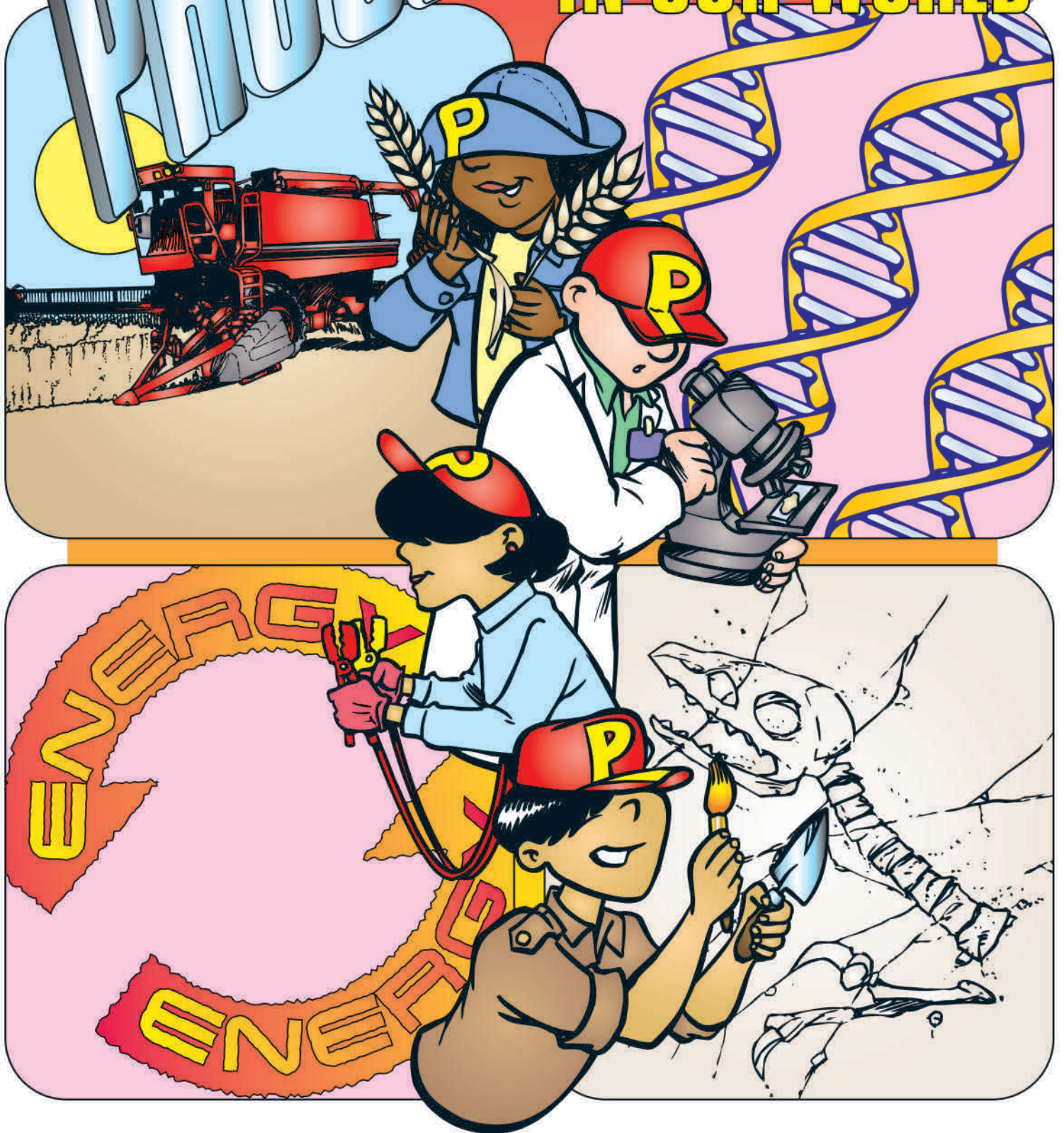


# UNDERSTANDING PHOSPHORUS IN OUR WORLD





THE THREE BOOKS IN THIS SERIES ARE UNDERSTANDING NITROGEN IN OUR WORLD, UNDERSTANDING PHOSPHORUS IN OUR WORLD, AND UNDERSTANDING POTASSIUM 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 PHOSPHORUS IN OUR WORLD.

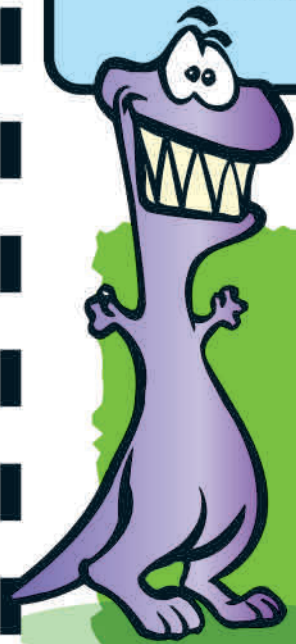
# UNDERSTANDING PHOSPHORUS IN OUR WORLD

A BOOKLET DEVELOPED FOR  
FOURTH THROUGH EIGHTH GRADE

ILLUSTRATIONS BY  
GREG CRAVENS



HEY! MY NAME IS **PHOSPHORUS!** DID YOU KNOW THAT PHOSPHORUS IS NATURALLY RECYCLED BY NATURE? SOME OF THE PHOSPHORUS IN YOUR BONES WAS PROBABLY PART OF THE BONES OF A DINOSAUR 60 MILLION YEARS AGO OR SO! HOW DO YOU THINK ANCIENT PHOSPHORUS WOULD GET FROM A DINOSAUR'S BONES INTO YOUR BONES? WHERE WOULD IT BE IN THE MILLIONS OF YEARS BETWEEN BEING PART OF A DINOSAUR AND PART OF YOU? HOW WOULD PHOSPHORUS TRAVEL? READ THIS BOOK TO DISCOVER HOW!





**DEFICIENT**-LACKING A NECESSARY NUTRIENT OR MINERAL.

**GEOGRAPHIC INFORMATION SYSTEM (GIS)**- ORGANIZED SETS OF COMPUTER HARDWARE, SOFTWARE, AND PROCEDURES DESIGNED TO HELP COLLECT, ANALYZE AND MANAGE DATA REFERENCED TO SPECIFIC LOCATIONS.

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

**INSOLUBLE**-SOMETHING THAT DOES NOT DISSOLVE IN WATER.

**MINERAL**-A MIXTURE OF NATURALLY OCCURRING INORGANIC COMPOUNDS OFTEN MINED FOR THE USEFUL SUBSTANCES THEY CONTAIN.

**NUTRIENT**-FOOD FOR PLANTS AND ANIMALS.

**RECYCLE**-TO PASS THROUGH A SERIES OF CHANGES FOR REUSE.

**SITE-SPECIFIC MANAGEMENT**-OVERALL CARE OF THE SOIL AND PLANTS FOLLOWING A SCIENCE-BASED DIAGNOSIS OF SPECIFIC SOIL AND PLANT CHARACTERISTICS.

**TILLAGE**-BREAKING UP OF SOIL FOR FARM PURPOSES.

**UPTAKE**- TO REMOVE DIRECTLY FROM THE SOIL BY PLANT ROOTS.

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

THESE ARE WORDS THAT WILL SHOW UP FROM TIME TO TIME IN THIS BOOK. CHECK THEM OUT NOW SO THEY DON'T SNEAK UP ON YOU WHILE YOU'RE READING LATER.





MY NAME IS  
PHOSPHORUS.

SCIENTISTS,  
FARMERS AND OTHER  
EDUCATED TYPES CALL  
ME BY MY CHEMICAL  
SYMBOL 'P'.

PHOSPHORUS IS AN ESSENTIAL  
ELEMENT IN NATURE. I'M REQUIRED BY  
BOTH PLANTS AND ANIMALS. (THAT  
MEANS YOU, TOO.) EVERY LIVING THING  
THAT HAS EVER BEEN: EVERY BUG,  
DINOSAUR, BIRD AND PERSON YOU  
HAVE EVER HEARD OF OR EVER  
WILL HEAR OF NEEDS  
PHOSPHORUS! I'M  
EVERYWHERE!







PHOSPHORUS OCCURS IN NATURAL GEOLOGIC DEPOSITS, PHOSPHATE SALTS AND MINERALS, AND PHOSPHATE ROCK ORE. THERE ARE VAST DEPOSITS IN THE U.S. AND OTHER PARTS OF THE WORLD.



THE **P** IN PHOSPHATE ROCK ORE IS VERY INSOLUBLE AND NOT VERY AVAILABLE FOR USE BY PLANTS. DURING PROCESSING, THE ORE IS TREATED WITH ACIDS TO MAKE THE **P** MORE AVAILABLE AND TO INCREASE THE **P** CONTENTS OF THE VARIOUS FERTILIZER PRODUCTS. THIS MAKES THE FERTILIZER MORE ECONOMICAL TO TRANSPORT AND MORE USEFUL TO FARMERS.







BECAUSE PHOSPHORUS IS ONE OF THE EARTH'S CRITICAL NATURAL RESOURCES, WE HAVE TO BE CAREFUL IN HOW WE TAKE CARE OF IT. WE AREN'T GOING TO RUN OUT TOMORROW, BUT IT IS OUR RESPONSIBILITY TO FUTURE GENERATIONS TO PROTECT AND CONSERVE WHAT WE FIND ON THE EARTH. BY USING P WISELY, FARMERS ARE DOING THEIR PART TO CONSERVE A NATURAL RESOURCE WHILE FEEDING A GROWING WORLD POPULATION.







ANIMAL MANURES ARE ANOTHER SOURCE OF P AND OTHER PLANT NUTRIENTS. THEY ALSO ADD ORGANIC MATTER TO THE SOIL. THERE ARE MILLIONS OF ANIMALS...CATTLE, HOGS, CHICKENS, TURKEYS... THAT PRODUCE MILLIONS OF TONS OF MANURE EACH YEAR. MUCH OF THIS MANURE IS COLLECTED AND RECYCLED ON FARM LAND.

THE NUTRIENT CONTENTS OF MANURES VARY AND ARE NOT TOO PREDICTABLE. IT IS DIFFICULT AND EXPENSIVE TO TRANSPORT AND APPLY MANURES. (BESIDES, THEY DON'T SMELL TOO GOOD EITHER.) HOWEVER, THEY ARE VALUABLE NUTRIENT SOURCES. THEIR PROPER USE ON AGRICULTURAL LAND HELPS TO GROW OUR CROPS AND REDUCES THE CHANCES THAT THE MANURES WILL BE WASHED INTO OUR RIVERS AND STREAMS.

USING ANIMAL MANURES PROPERLY SERVES TWO GOOD PURPOSES. IT INCREASES CROP PRODUCTION BY SUPPLYING P AND OTHER PLANT NUTRIENTS AND HELPS TO PROTECT THE ENVIRONMENT.

OTHER POTENTIAL SOURCES OF PLANT NUTRIENTS INCLUDE YARD WASTES.... GRASS CLIPPINGS AND GROUND UP BRANCHES AND LEAVES FROM TREES AND SHRUBS. THESE MATERIALS CAN BE PROCESSED AND APPLIED TO AGRICULTURAL LANDS RATHER THAN TAKING UP SO MUCH SPACE IN LANDFILLS.



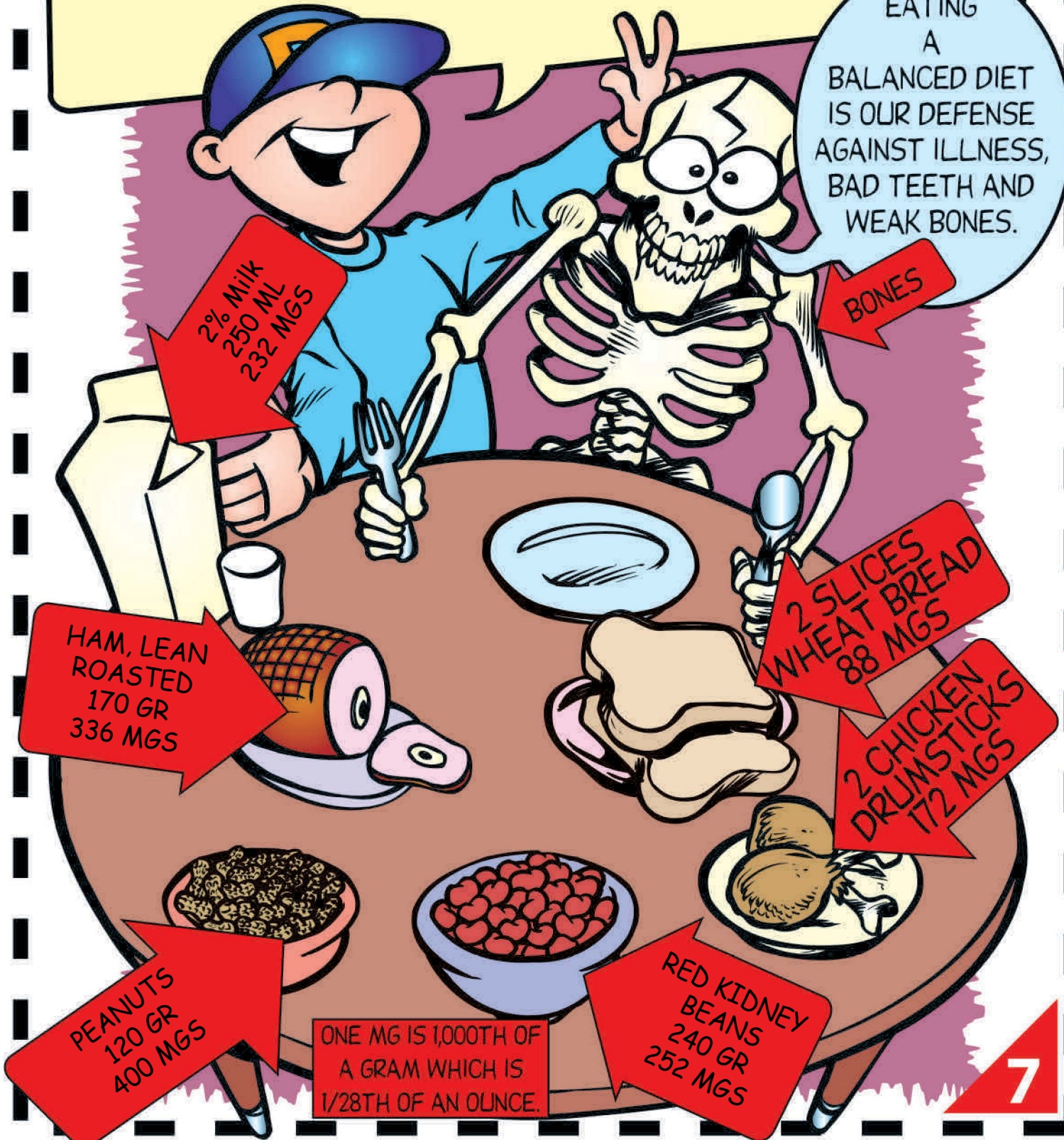
HUMAN WASTES ARE ALSO BEING CHEMICALLY TREATED AND APPLIED TO AGRICULTURAL LANDS. HUMAN WASTES ARE BECOMING MORE AND MORE OF A PROBLEM IN TOWNS AND CITIES AS OUR POPULATION GROWS.



## UNDERSTANDING PHOSPHORUS IN OUR WORLD.

PHOSPHORUS IS THE SECOND MOST ABUNDANT MINERAL NUTRIENT IN THE HUMAN BODY. NEARLY 80% OF THE PHOSPHORUS IN HUMANS IS FOUND IN BONES AND TEETH. THE REMAINDER IS WIDELY DISTRIBUTED IN COMBINATION WITH PROTEINS, FATS AND SALTS IN EVERY CELL. HOW CAN WE BE SURE WE ARE GETTING ENOUGH PHOSPHORUS? BY GOOD HEALTH HABITS. EATING RIGHT. PHOSPHORUS IS IN MEATS, DAIRY PRODUCTS, FRUITS, NUTS AND VEGETABLES!

EATING A BALANCED DIET IS OUR DEFENSE AGAINST ILLNESS, BAD TEETH AND WEAK BONES.



2% Milk  
250 ML  
232 MGS

BONES

HAM, LEAN  
ROASTED  
170 GR  
336 MGS

2 SLICES  
WHEAT BREAD  
88 MGS

2 CHICKEN  
DRUMSTICKS  
172 MGS

PEANUTS  
120 GR  
400 MGS

ONE MG IS 1,000TH OF  
A GRAM WHICH IS  
1/28TH OF AN OUNCE.

RED KIDNEY  
BEANS  
240 GR  
252 MGS



WHAT IS IT THAT MAKES FOOD FOR PLANTS?

# PHOTOSYNTHESIS

PHOTOSYNTHESIS WOULD NOT BE POSSIBLE WITHOUT P. THE SUN'S LIGHT ENERGY WOULD BE OF LITTLE VALUE TO PLANTS WITHOUT P. PHOSPHORUS IS INDEED THE ENERGIZER IN FOOD PRODUCTION. IT IS ALSO ONE OF THE BUILDING BLOCKS OF GENES AND CHROMOSOMES. IT IS INVOLVED IN SEED GERMINATION. PHOSPHORUS WORKS TO HELP PLANTS USE OTHER NUTRIENTS MORE EFFICIENTLY.

ENERGY FROM THE SUN.

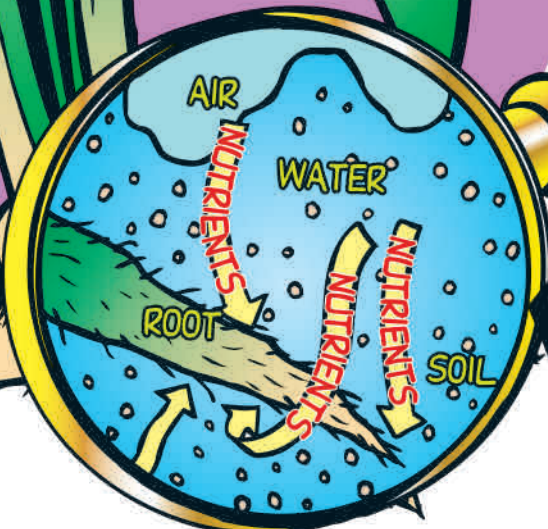
HIGH ENERGY P COMPOUNDS CREATE MORE PLANT TISSUE AND GRAIN.

BREAKDOWN OF SUGAR (RESPIRATION) RELEASES ENERGY WHICH IS TRAPPED AS HIGH-ENERGY P COMPOUNDS

WATER, SOLAR ENERGY, & CARBON DIOXIDE BECOME SUGAR & OXYGEN.

NITROGEN, PHOSPHORUS, POTASSIUM, CALCIUM, OTHER NUTRIENTS FROM THE SOIL & FERTILIZERS.

WATER WRAPPED AROUND SOIL PARTICLES AND PLANT ROOTS ALLOWS NUTRIENTS TO MOVE FROM THE SOIL TO THE ROOTS.



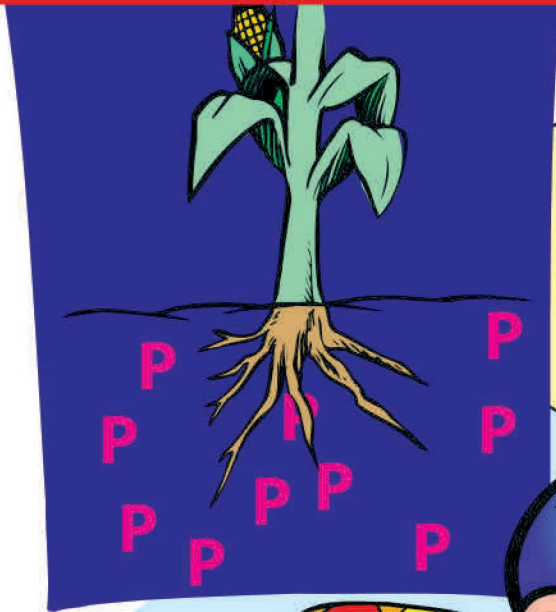


THE PROBLEMS OF PLANTS NOT GETTING ENOUGH PHOSPHORUS ARE TWO-FOLD.  
1. THE HEALTH OF THE PLANT SUFFERS.  
2. THE EFFECT ON THE ENVIRONMENT.  
INCREASED EROSION, LOSS OF SOIL PRODUCTIVITY, POLLUTION...

THE EFFECT OF PROPER USE OF P AND OTHER INPUTS ON CROPS.





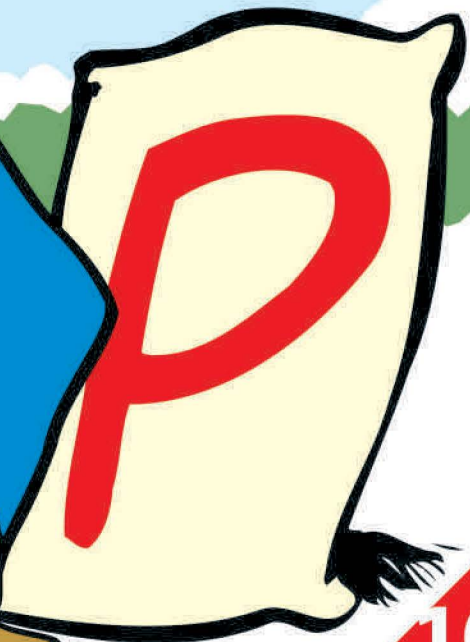


PLANT ROOT UPTAKE IS DEPENDENT ON AN ADEQUATE SUPPLY OF SOIL P. PHOSPHORUS IS RELATIVELY INSOLUBLE IN WATER. THE WATER IN MOST SOILS CONTAINS ONLY A FEW KILOS OF P PER ACRE. SO FOR A CROP SUCH AS CORN, SOILS MUST COMPLETELY REPLACE ALL OF THE P IN THE SOIL WATER 2 TO 3 TIMES EACH DAY TO MEET THE CROP'S DEMAND FOR P.

IMAGINE TRYING TO SWALLOW A BIG OL' PILL WITH ONLY A LITTLE WATER!

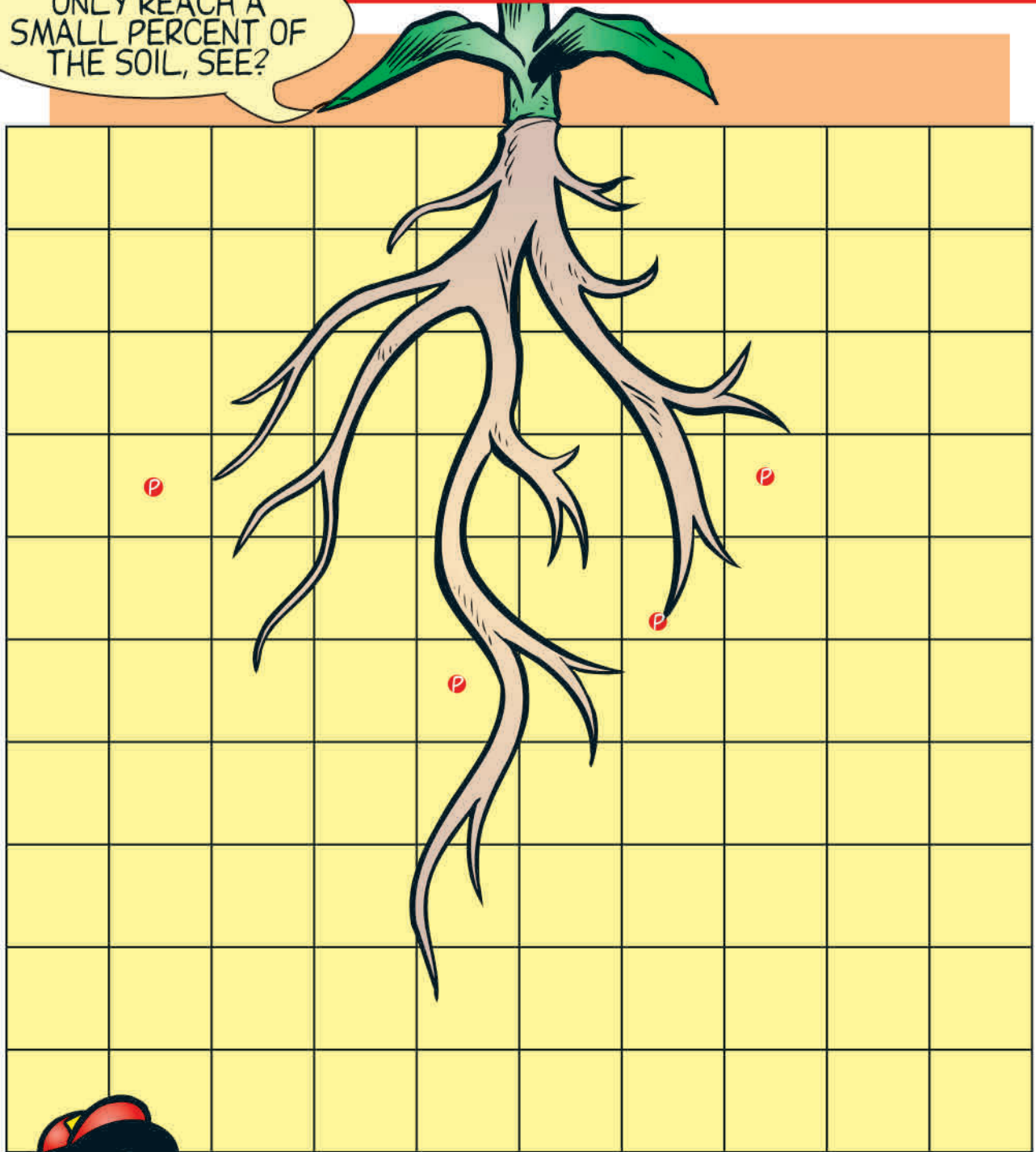
PLANT ROOTS ONLY REACH A SMALL PERCENT OF THE SOIL.

SOILS CONTAIN LARGE AMOUNTS OF P BUT IT IS NOT VERY AVAILABLE TO PLANTS. MOVEMENT OF P IN SOIL IS SO LIMITED THAT MOST OF IT CAN'T GET CLOSE ENOUGH TO A ROOT FOR A PLANT TO TAKE IT UP.





CROP ROOTS ONLY REACH A SMALL PERCENT OF THE SOIL, SEE?



SUPPOSE EACH OF THE 100 BLOCKS REPRESENT 1% OF THE SOIL WHERE PLANTS ARE GROWING. PLANT ROOTS ONLY REACH A SMALL PART OF EACH BLOCK. IN FACT THEY DON'T REACH MOST OF THEM AT ALL. IF THE AMOUNT OF P PRESENT IS TOO SMALL, THE PLANT MIGHT NEVER FIND THE P.



WHAT HAPPENS TO PLANTS THAT ARE P DEFICIENT?  
THEY ARE SICKLY, STUNTED, SPINDLY, AND WEAK.  
PHOSPHORUS IMPROVES CROP QUALITY AND PROTECTS  
PLANTS AGAINST DISEASE. IT HELPS PLANTS OVERCOME  
THE EFFECTS OF COLD WINTER TEMPERATURES, DROUGHT  
AND OTHER ENVIRONMENTAL STRESSES.



IF PLANTS  
BECOME P-  
DEFICIENT, THEY USE  
WATER POORLY.

TAKE TWO OF  
THESE WITH WATER  
AND CALL ME IN THE  
MORNING.



P DEFICIENT  
PLANTS ARE MORE  
SUSCEPTIBLE TO  
DISEASE.



I DON'T  
FEEL  
SO GOOD.



P DEFICIENT PLANTS HAVE LOWER NUTRITIONAL VALUE FOR ANIMALS AND HUMANS (THIS MEANS YOU). IF YOU HAD TO PICK BETWEEN THESE TWO CARROTS, WOULD YOU PICK 'A' OR 'B'? GUESS WHICH CARROT HAS MORE PHOSPHORUS THAN THE OTHER? IF YOU SAID 'B', THEN YOU JUST THINK YOU'RE BEING FUNNY, BECAUSE NOBODY WOULD REALLY THINK THAT THE UGLY 'B' CARROT HAS MORE GOOD OL' PHOSPHORUS THAN THE HEALTHY 'A' CARROT! CHOOSE YOUR GOOD NUTRITION! EAT FOOD THAT IS HEALTHY SO YOU CAN BE HEALTHY!

PICK A CARROT!



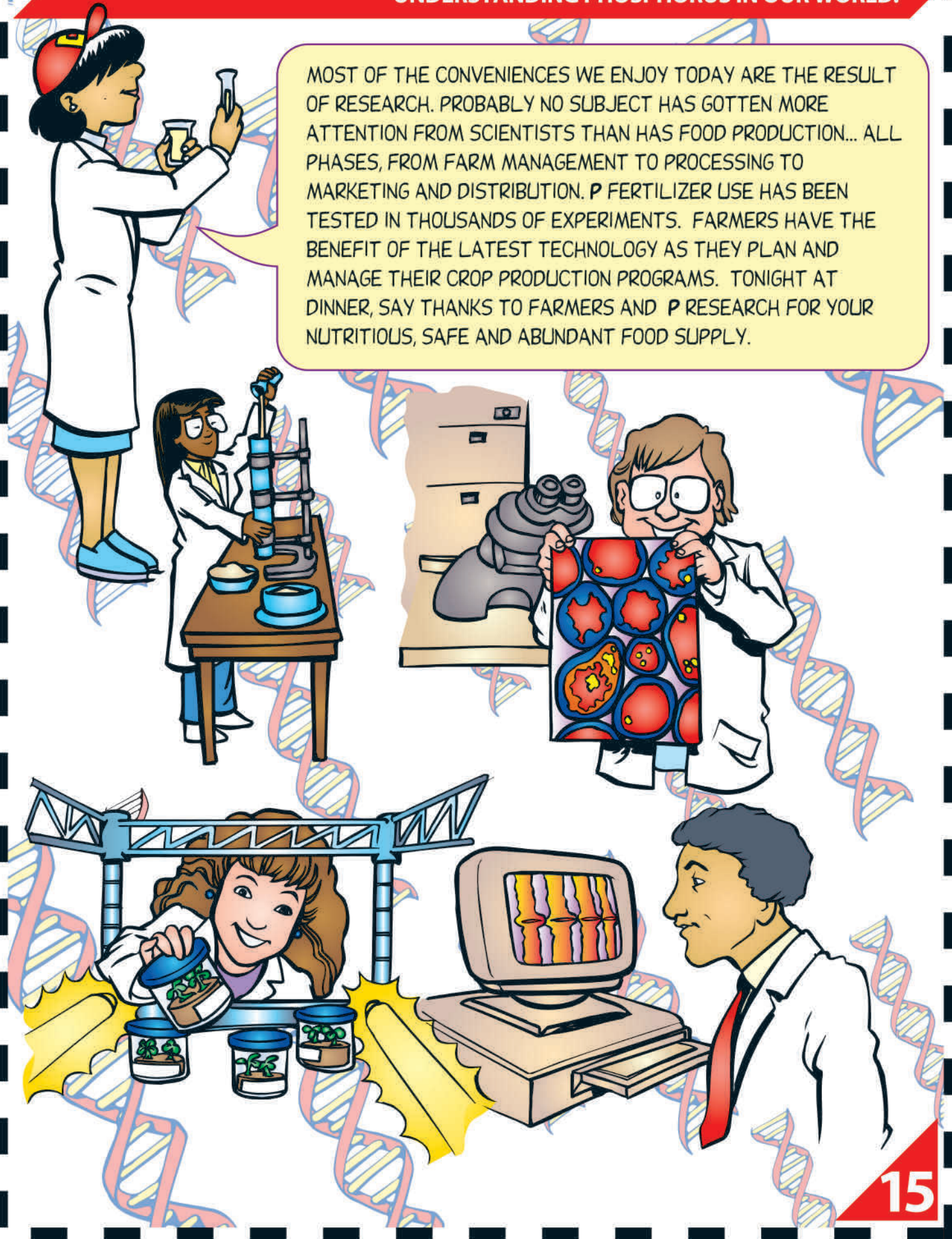


PHOSPHORUS COMPOUNDS HELP IN DIRECTING WHERE ENERGY FROM FOOD THAT PLANTS AND ANIMALS TAKE IN WILL BE USED. FOR INSTANCE, IN PLANTS, CARBON DIOXIDE FROM THE AIR AND WATER FROM THE SOIL ARE BROKEN DOWN AND CONVERTED TO SIMPLE SUGARS THAT THE PLANT NEEDS. PHOSPHORUS COMPOUNDS ARE NEEDED IN PLANT PHOTOSYNTHESIS TO "REPACKAGE" AND TRANSFER ENERGY!



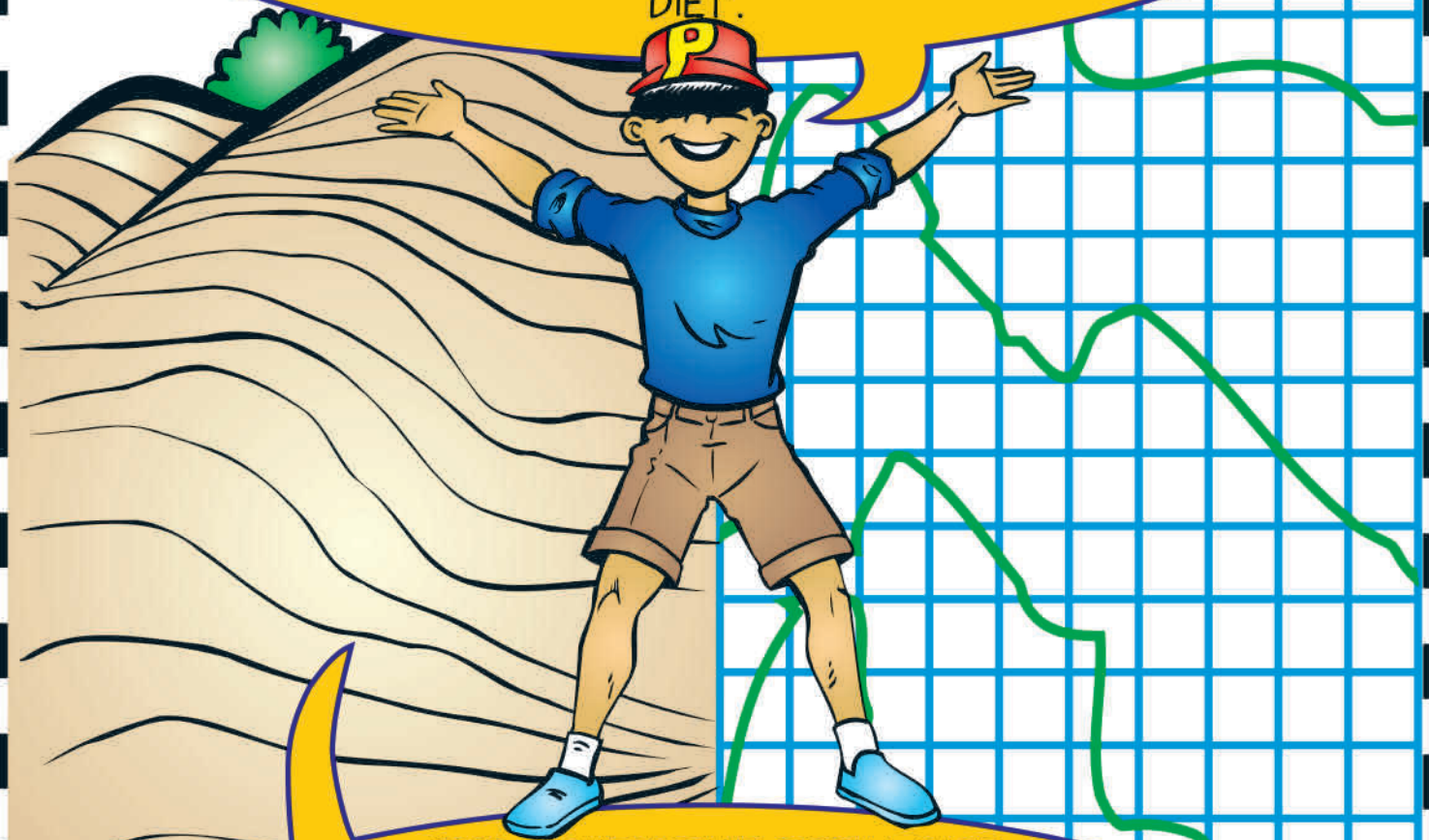


MOST OF THE CONVENIENCES WE ENJOY TODAY ARE THE RESULT OF RESEARCH. PROBABLY NO SUBJECT HAS GOTTEN MORE ATTENTION FROM SCIENTISTS THAN HAS FOOD PRODUCTION... ALL PHASES, FROM FARM MANAGEMENT TO PROCESSING TO MARKETING AND DISTRIBUTION. P FERTILIZER USE HAS BEEN TESTED IN THOUSANDS OF EXPERIMENTS. FARMERS HAVE THE BENEFIT OF THE LATEST TECHNOLOGY AS THEY PLAN AND MANAGE THEIR CROP PRODUCTION PROGRAMS. TONIGHT AT DINNER, SAY THANKS TO FARMERS AND P RESEARCH FOR YOUR NUTRITIOUS, SAFE AND ABUNDANT FOOD SUPPLY.





A FIELD ISN'T JUST A FIELD. EACH ONE CAN HAVE DIFFERENT KINDS OF SOIL. SOME SOILS ARE SANDY; OTHERS HAVE MORE CLAY. SOME ARE LIGHT IN COLOR; OTHERS ARE DARK. SOME SOILS ARE SHALLOW WHILE OTHERS ARE DEEP. EACH OF THESE FACTORS INFLUENCES SOIL NUTRIENT LEVELS AND NUTRIENT REQUIREMENTS OF THE CROPS. THAT'S WHY IT IS IMPORTANT FOR FARMERS TO HAVE THE CHOICE OF APPLYING VARIABLE RATES OF NUTRIENTS...SO PLANTS GROWN IN EACH SOIL WITHIN A FIELD GET A 'BALANCED DIET'.



GOOD FARMERS TAKE SPECIAL CARE OF THE LAND THEY FARM. THEY USE SCIENTIFIC METHODS OF TESTING SOILS AND PLANTS TO DETERMINE NUTRIENT REQUIREMENTS OF THEIR CROPS. THIS ALLOWS THEM TO USE NUTRIENTS SUCH AS P IN THE MOST EFFICIENT, ENVIRONMENTALLY FRIENDLY MANNER. NOW, HOWEVER, NEW TECHNOLOGY IS ALLOWING FARMERS TO BE EVEN MORE PRECISE IN APPLYING P AND OTHER NUTRIENTS. USING GPS AND GIS, ALONG WITH SOIL TESTING, THEY CAN APPLY VARIABLE RATES OF NUTRIENTS AS THEIR EQUIPMENT MOVES ACROSS THE FIELD, CHANGING RATES 'ON-THE-GO'.



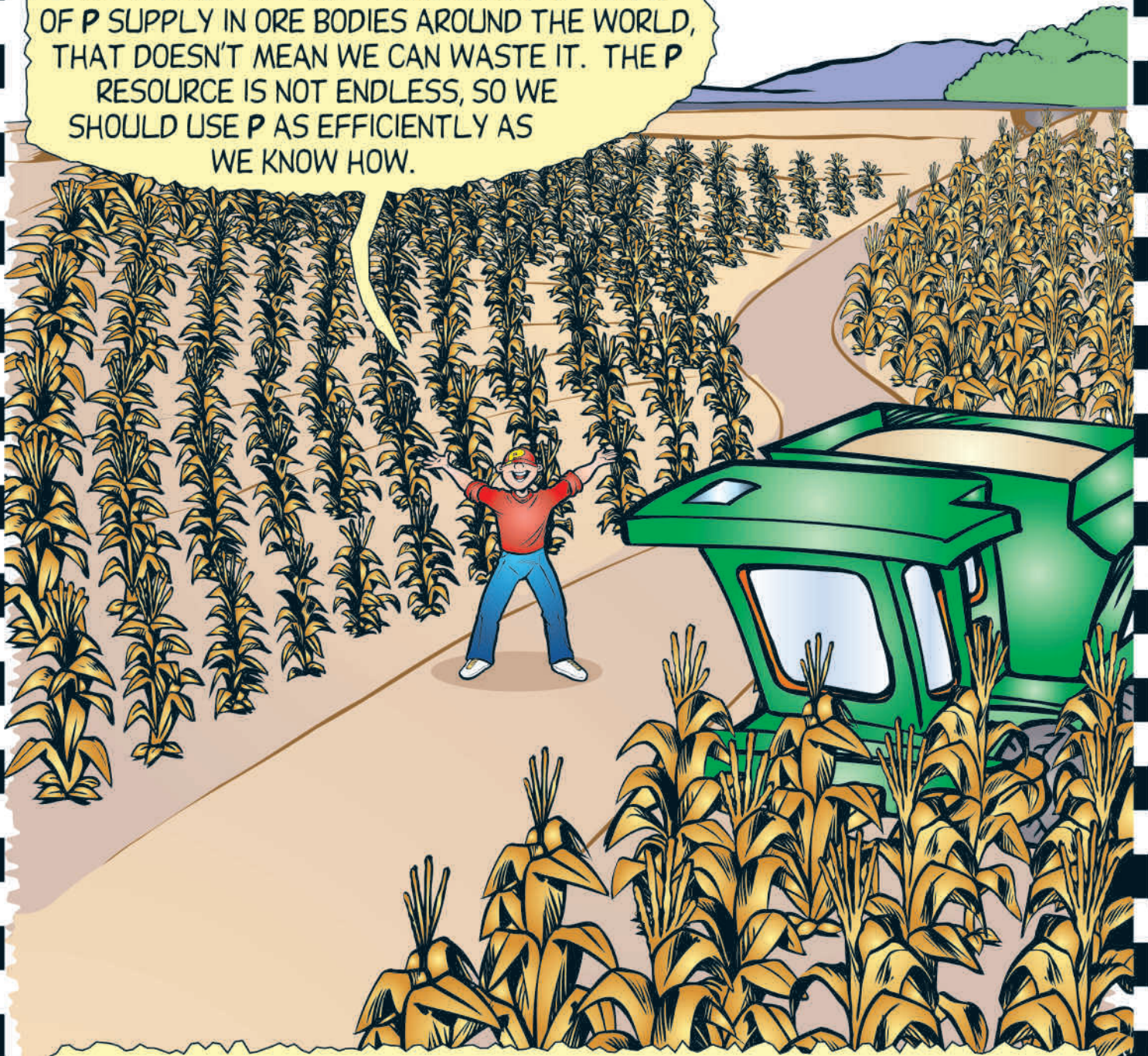
USING SPACE-AGE TECHNOLOGY, IT IS POSSIBLE TO VARY THE RATE OF NUTRIENTS APPLIED AS EQUIPMENT MOVES ACROSS THE FIELD.



USING SOIL TEST RESULTS FROM THE LAB AND NEW TECHNOLOGY, EQUIPMENT CAN BE PROGRAMMED TO PUT OUT JUST THE RIGHT AMOUNTS OF NUTRIENTS. RATES OF NUTRIENTS CHANGE AS THE EQUIPMENT MOVES ACROSS THE FIELD. COMPUTERS AND SATELLITES ARE VERY ACCURATE AND HELP THE FARMER TO PINPOINT WHERE CHANGES IN NUTRIENT RATES NEED TO BE MADE.



EVEN THOUGH WE HAVE THOUSANDS OF YEARS OF P SUPPLY IN ORE BODIES AROUND THE WORLD, THAT DOESN'T MEAN WE CAN WASTE IT. THE P RESOURCE IS NOT ENDLESS, SO WE SHOULD USE P AS EFFICIENTLY AS WE KNOW HOW.



THE GIS AND GPS TECHNOLOGY ALSO HELPS FARMERS TRACK CROP YIELDS ON-THE-GO AS HARVESTING EQUIPMENT MOVES ACROSS FIELDS. THAT MEANS YIELD VARIATIONS IN SPECIFIC AREAS OF FIELDS CAN BE IDENTIFIED. FARMERS CAN THEN DEVELOP SITE-SPECIFIC PLANS TO IMPROVE CROP YIELDS AND PRODUCTION EFFICIENCY, WHILE AT THE SAME TIME, THEY PROTECT THE ENVIRONMENT. SITE-SPECIFIC MANAGEMENT INCLUDES NUTRIENT MANAGEMENT, AND THAT MEANS P CAN BE USED MOST EFFICIENTLY...NOT TOO MUCH, NOT TOO LITTLE, BUT JUST THE RIGHT AMOUNTS ON EACH FARM.



GOOD SOIL CONSERVATION PRACTICES ARE IMPORTANT IN AGRICULTURE. PHOSPHORUS IS USUALLY ATTACHED TO SOIL PARTICLES. SO IF SOIL IS ERODED, IT CAN CARRY PHOSPHORUS WITH IT, BECOMING PART OF THE SEDIMENT IN WATERWAYS. NO-TILL OR OTHER TYPES OF "CONSERVATION TILLAGE" ON SLOPING FIELDS AND GRASS BUFFERS CAN REDUCE PROBLEMS CAUSED BY EROSION.

YOU MAY HAVE HEARD THAT TOO MUCH PHOSPHORUS CAN GET INTO STREAMS OR LAKES AND CONTRIBUTE TO ALGAL BLOOMS AND SIMILAR CONCERNS. THERE CAN BE SEVERAL SOURCES OF PHOSPHORUS. AGRICULTURE IS ONE. FOLKS IN TOWNS AND CITIES ALSO SEND P TO OUR WATERWAYS...FROM THEIR LAWNS AND GARDENS, DISHWASHERS, LAUNDRY AND TOILETS.



# PHOSPHORUS IS A STARTER!



PHOSPHORUS AS A NUTRIENT IS SOMETIMES MOST VALUABLE TO PLANTS WHEN PUT NEAR THE SEED FOR EARLY PLANT HEALTH AND ROOT GROWTH. A STARTER FERTILIZER IS OFTEN HELPFUL WHEN SOILS ARE COLD AND WET, WHEN SEEDS ARE PLANTED IN EARLY SPRING, OR WHEN PLANTING IS IN A "CONSERVATION TILLAGE" SYSTEM.





ARE YOU HEALTHY? IF SO, IT IS LARGELY BECAUSE YOU EAT HEALTHY FOODS. YOU CAN'T BE HEALTHY BY EATING UNHEALTHY STUFF. THE FRUITS, NUTS, AND VEGETABLES YOU'VE EATEN MUST HAVE BEEN FULL OF PHOSPHORUS AND OTHER GOOD THINGS.



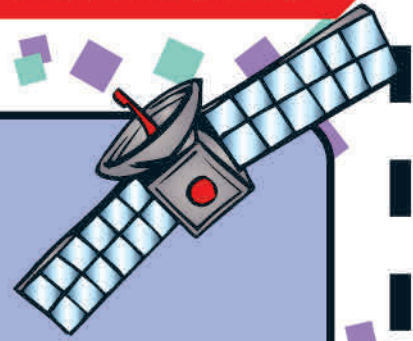
IF THE FOOD HAD PLENTY OF NUTRIENTS, IT WAS PROBABLY BECAUSE THE FARMERS ADDED THEM TO THE SOIL SO THAT THEY WOULD RAISE GOOD CROPS.



IF THIS FARMER ADDED THE RIGHT NUTRIENTS TO GET THE BEST CROPS, HE PROBABLY HAD HELP FROM LABS AND COMPUTERS.

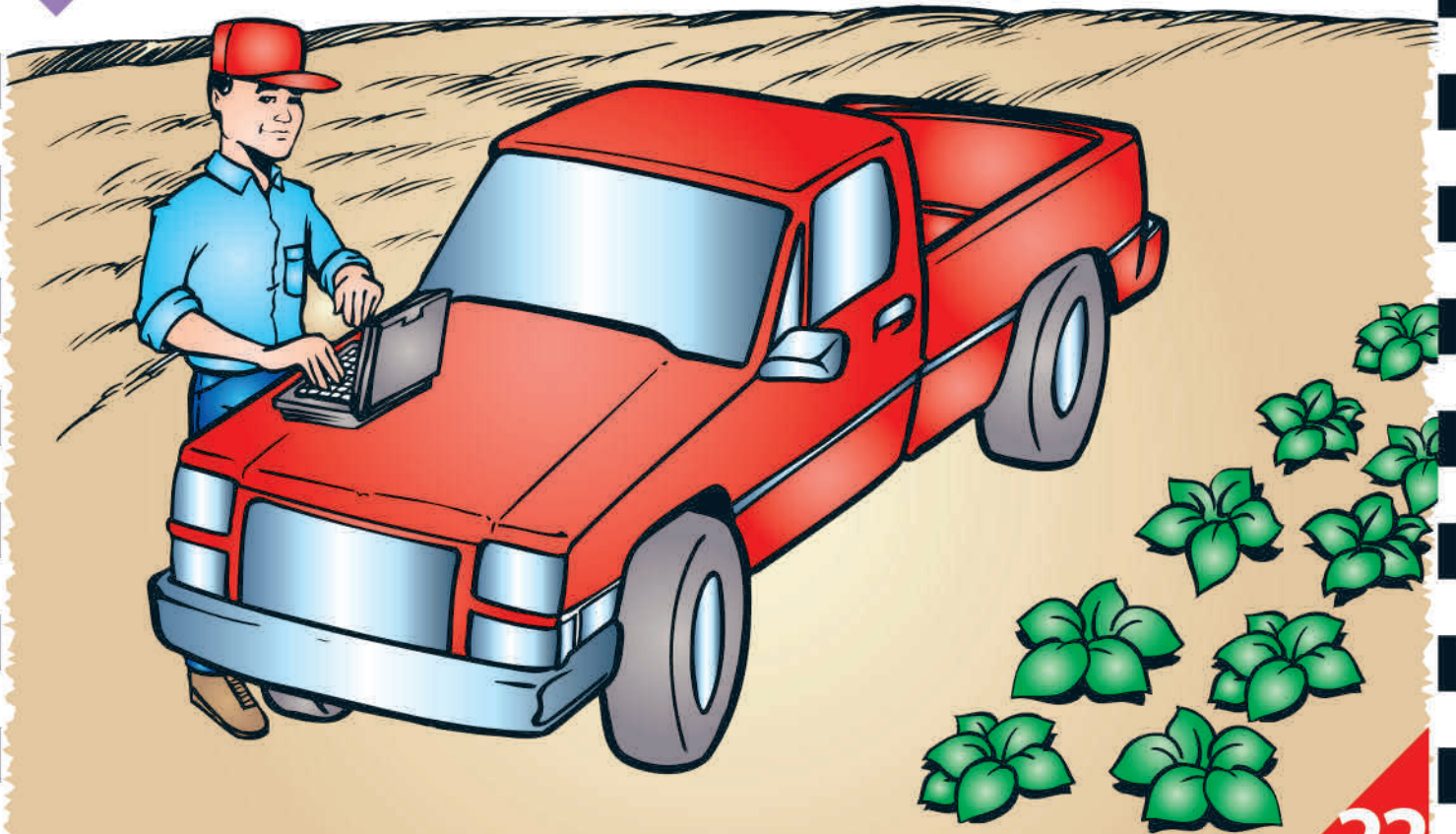


TO BE SUCCESSFUL, FARMERS MUST BE BUSINESS PEOPLE AS WELL AS TILLERS OF THE SOIL. MANY MUST FINANCE EACH CROP, PAYING OFF THEIR LOANS AT HARVEST-TIME WHEN THE CROP IS SOLD. THEY HAVE TO WATCH PRICES AND WEATHER AND MARKET CONDITIONS ALL OVER THE WORLD. THEY MUST KNOW WHEN TO SELL THEIR CROPS.



THE NEXT TIME YOU SEE A FARMER, TELL HIM OR HER HOW MUCH YOU APPRECIATE THE GOOD FOOD THEY SEND YOUR WAY.

SO REMEMBER... PHOSPHORUS INCREASES CROP YIELDS. THAT MEANS FARMERS CAN GROW MORE FOOD PER ACRE OF LAND. THEY CAN PRODUCE ABUNDANT, SAFE FOOD AT A REASONABLE PRICE AND STILL MAKE A PROFIT.





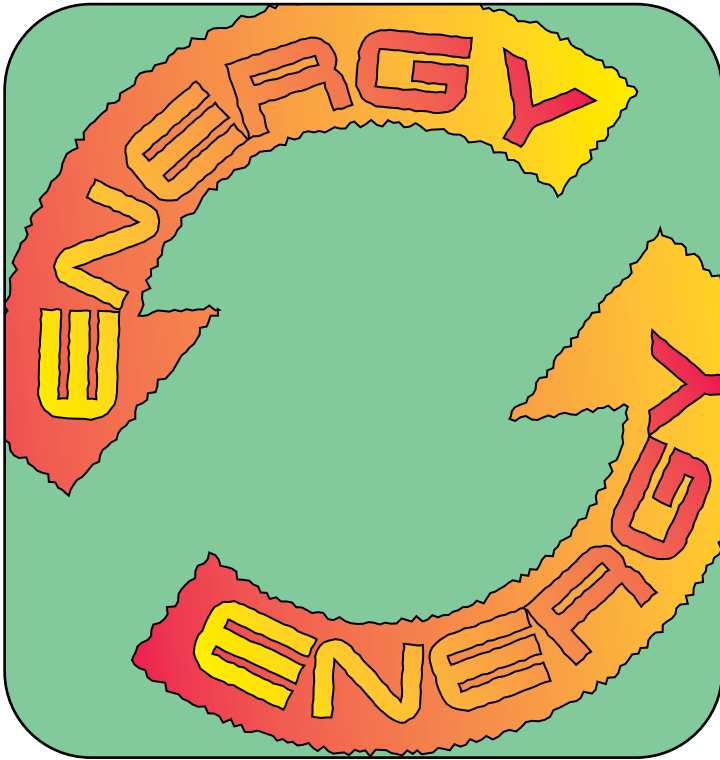
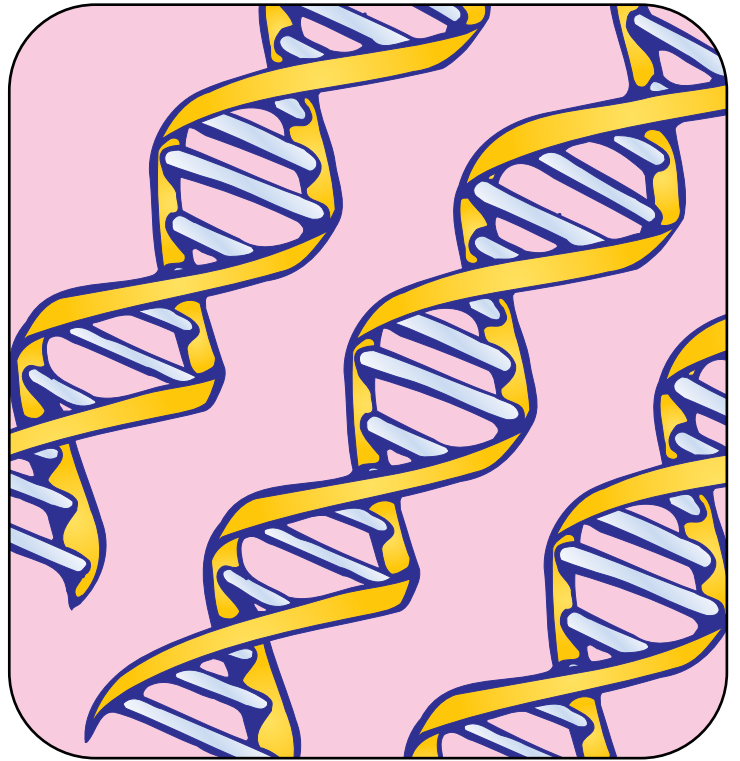
PHOSPHORUS IS ONE PLAYER ON A 17 MEMBER TEAM OF ESSENTIAL NUTRIENTS AND MINERALS. THEY ALL WORK TOGETHER TO KEEP PLANTS AND ANIMALS HEALTHY AND GROWING.











# UNDERSTANDING PHOSPHORUS IN OUR WORLD

**BROUGHT TO YOU BY:**

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