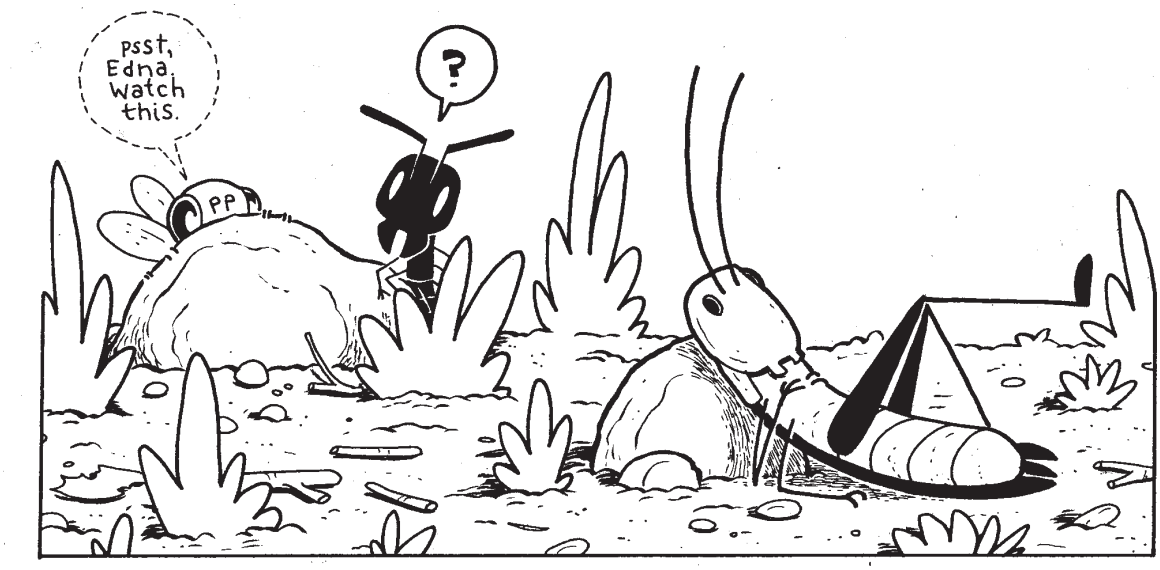
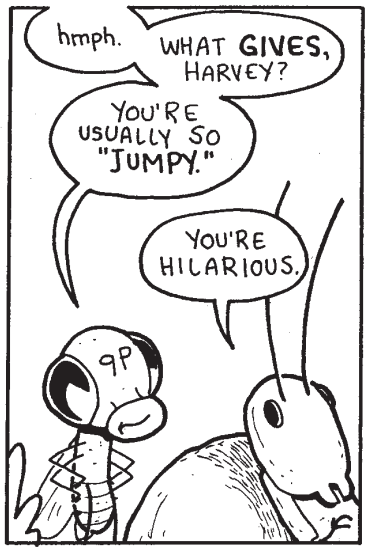
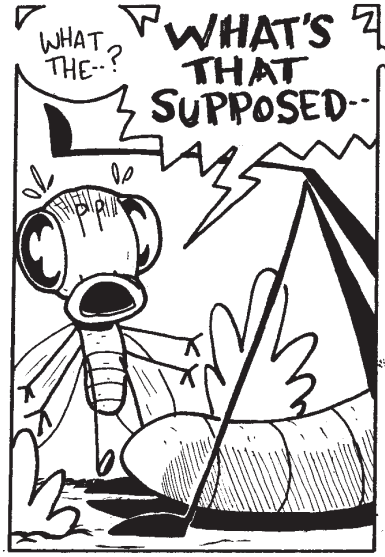
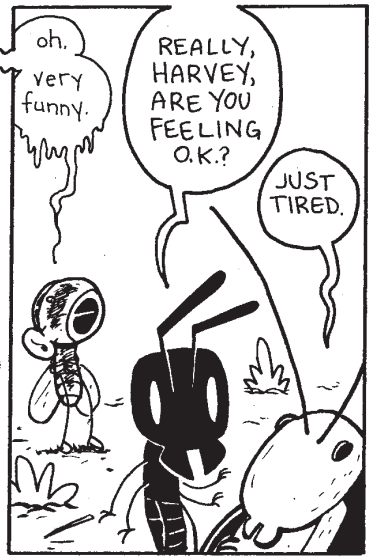

psst, Edna watch this.
?

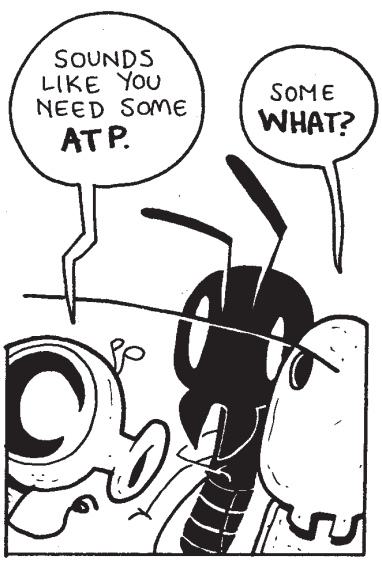

BOOGA-BOOGA!
HEY, WILBUR.


hmph.
WHAT GIVES, HARVEY?
YOU'RE USUALLY SO "JUMPY."
YOU'RE HILARIOUS.

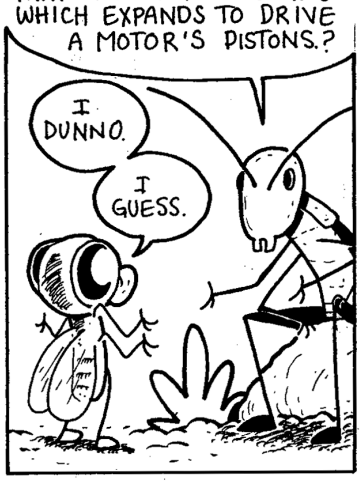

SERIOUSLY, I FIGURED THAT WOULD MAKE YOU LEAP A METER EASY. YOU'RE THE MOST HIGH-STRUNG BUG IN THE UNDERGROWTH.
NEXT TO YOU.

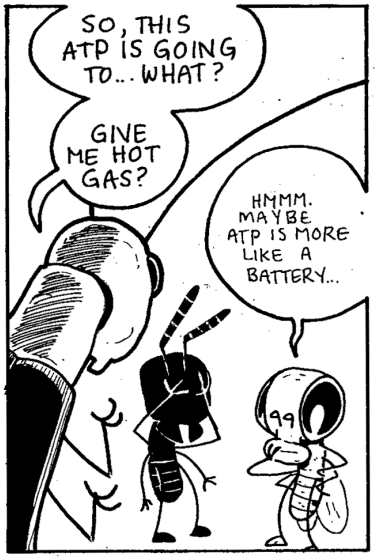

WHAT THE--?
WHAT'S THAT SUPPOSED--

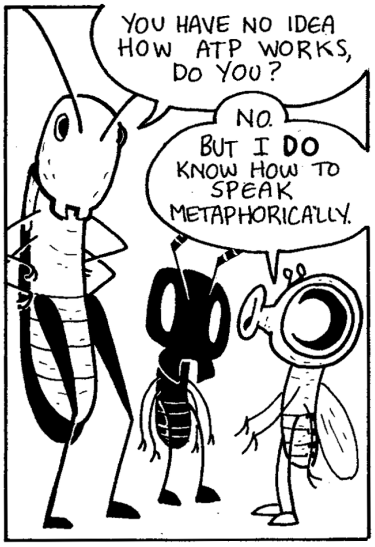

oh. very funny.
REALLY, HARVEY, ARE YOU FEELING O.K.?
JUST TIRED.

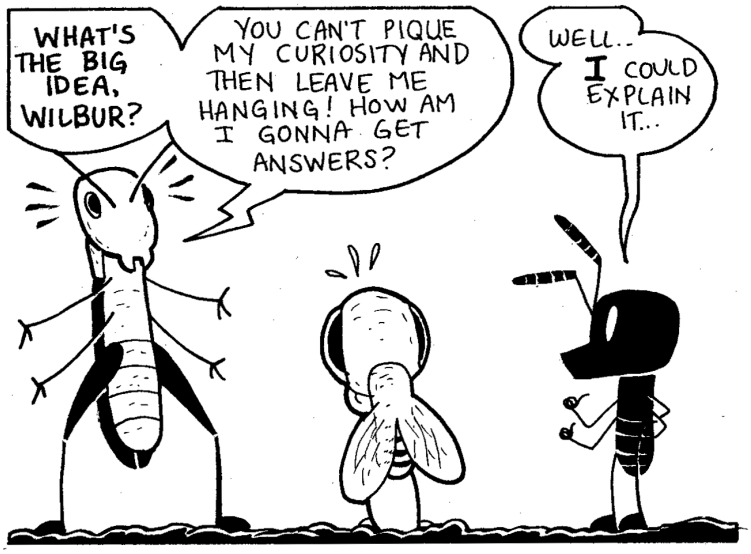

SOUNDS LIKE YOU NEED SOME ATP.
SOME WHAT?

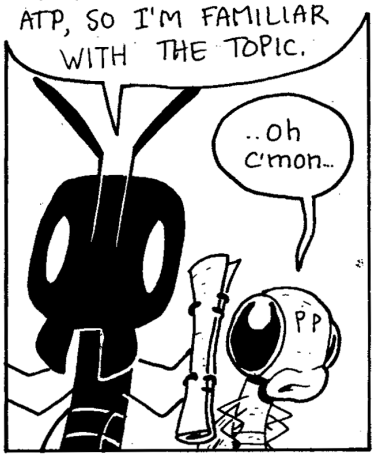

IT'S THE ENERGY SOURCE THAT MAKES YOUR BODY GO! GO! GO!
WHAT DOES THAT EVEN MEAN?
Y'KNOW- IT'S LIKE THE FUEL IN A CAR.
PP

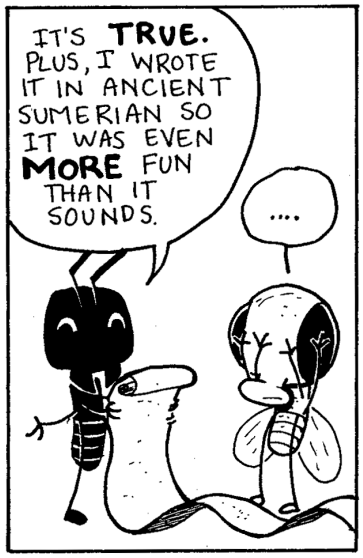

DON'T CARS USE FUEL TO IGNITE SMALL EXPLOSIONS THAT GENERATE HOT GAS WHICH EXPANDS TO DRIVE A MOTOR'S PISTONS.?
I DUNNO.
I GUESS.

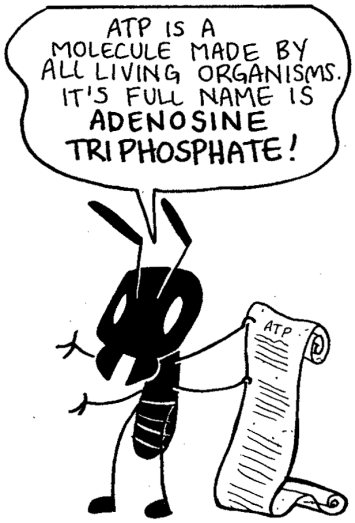

SO, THIS ATP IS GOING TO... WHAT?
GIVE ME HOT GAS?
HMMM. MAYBE ATP IS MORE LIKE A BATTERY...
99

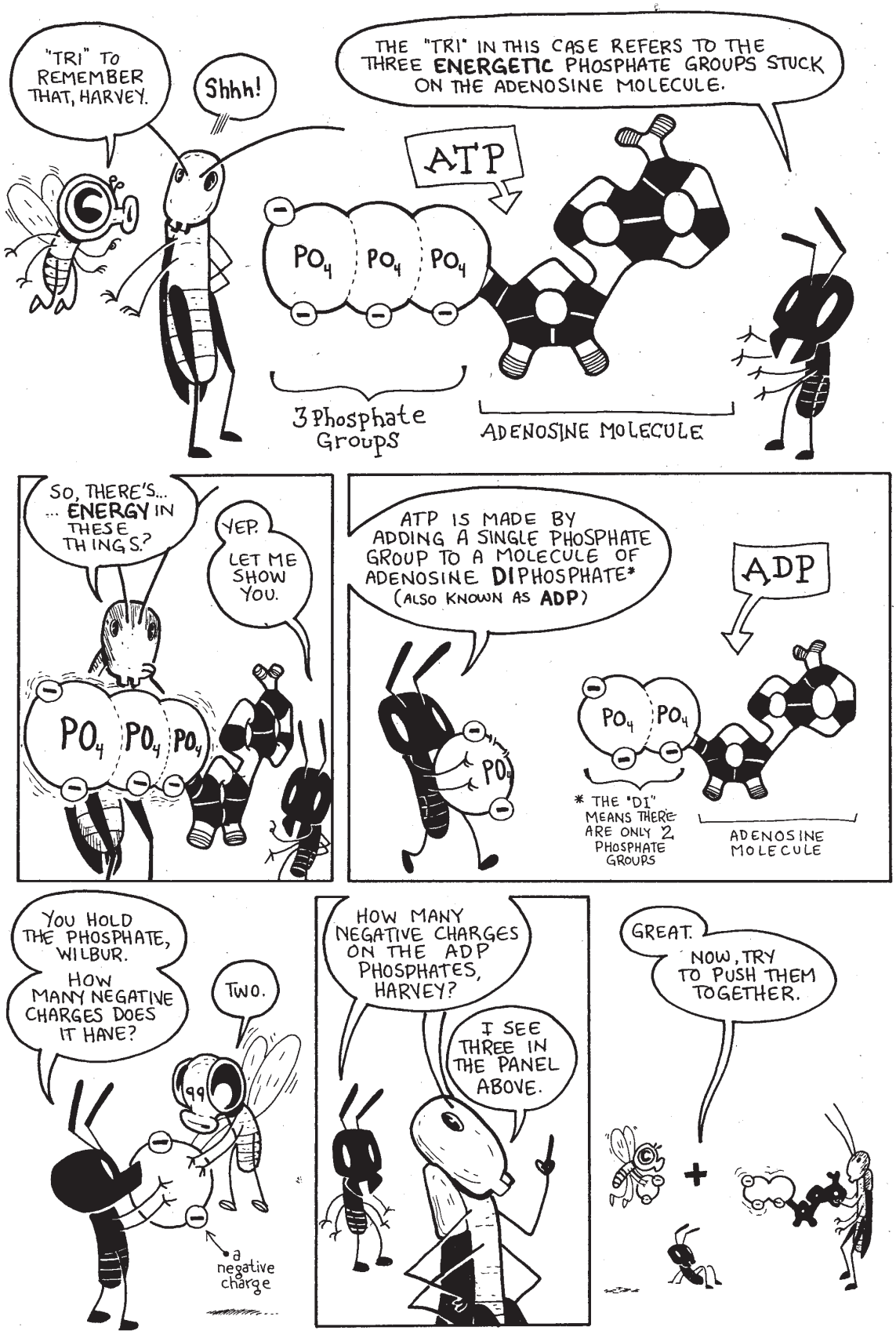

YOU HAVE NO IDEA HOW ATP WORKS, DO YOU?
NO. BUT I DO KNOW HOW TO SPEAK METAPHORICALLY.

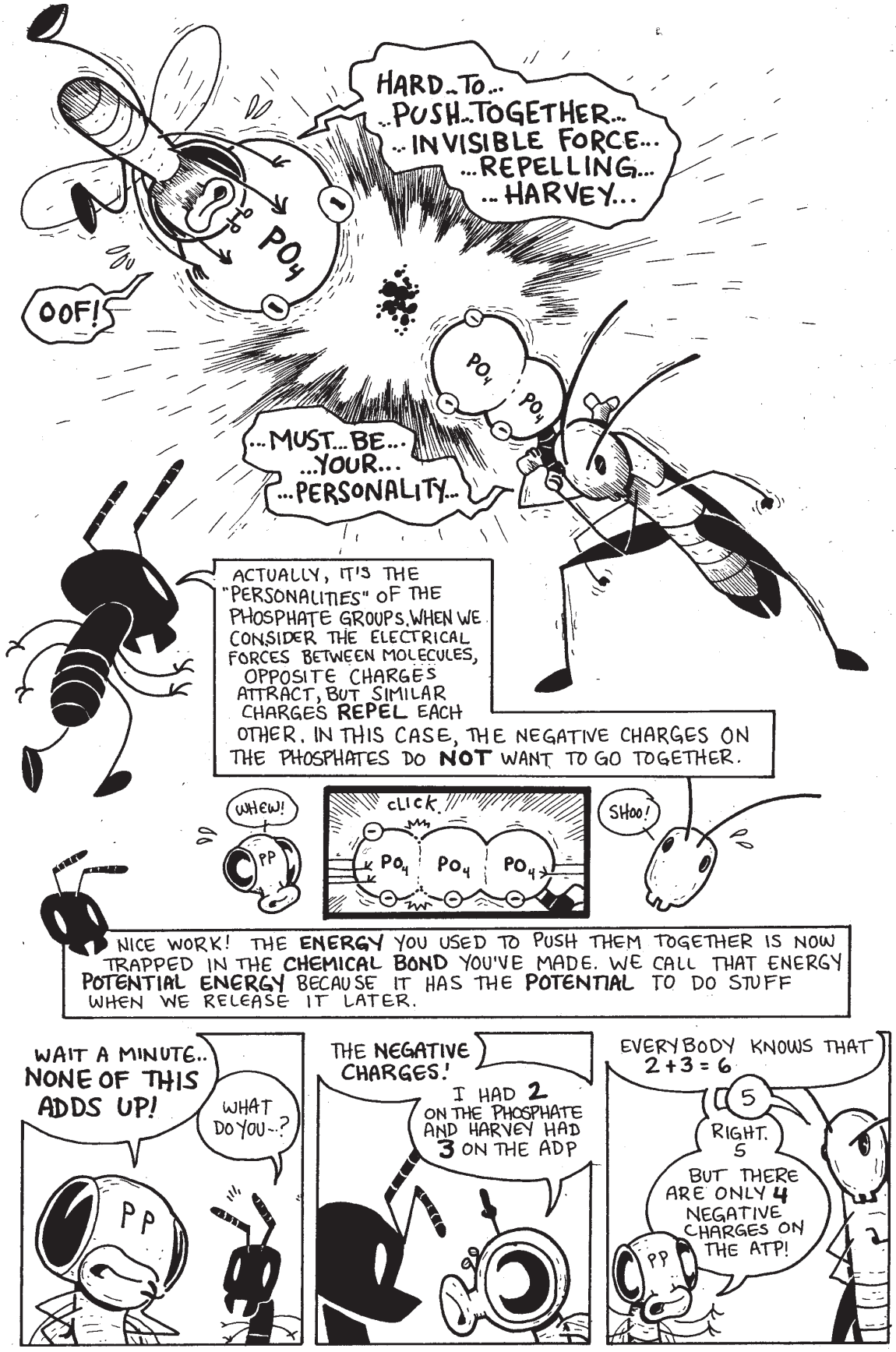

WHAT'S THE BIG IDEA, WILBUR?
YOU CAN'T PIQUE MY CURIOSITY AND THEN LEAVE ME HANGING! HOW AM I GONNA GET ANSWERS?
WELL.. I COULD EXPLAIN IT..

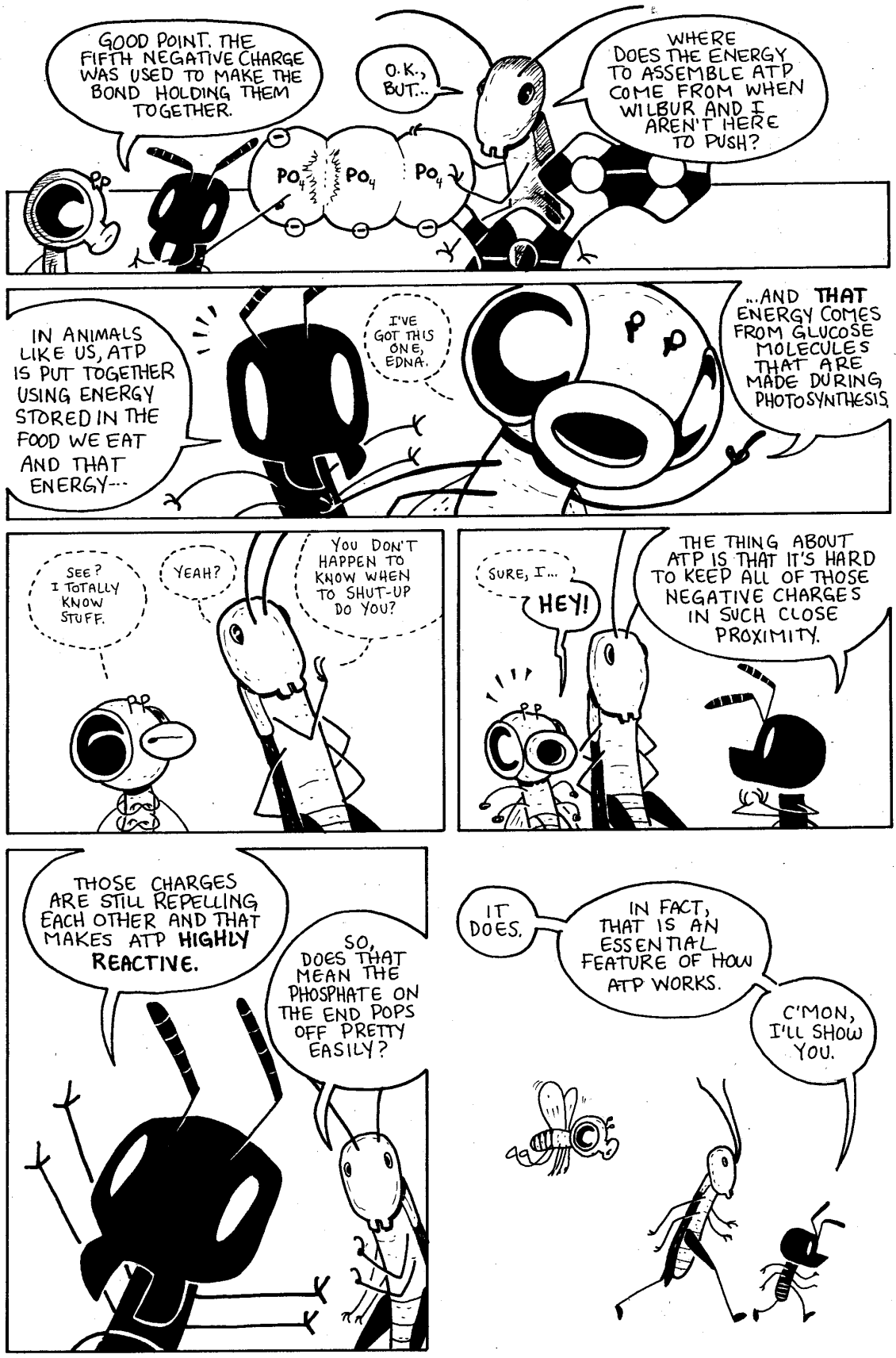

JUST LAST NIGHT I PUT THE FINISHING TOUCHES ON AN EPIC POEM ABOUT ATP, SO I'M FAMILIAR WITH THE TOPIC.
..oh c'mon...
PP

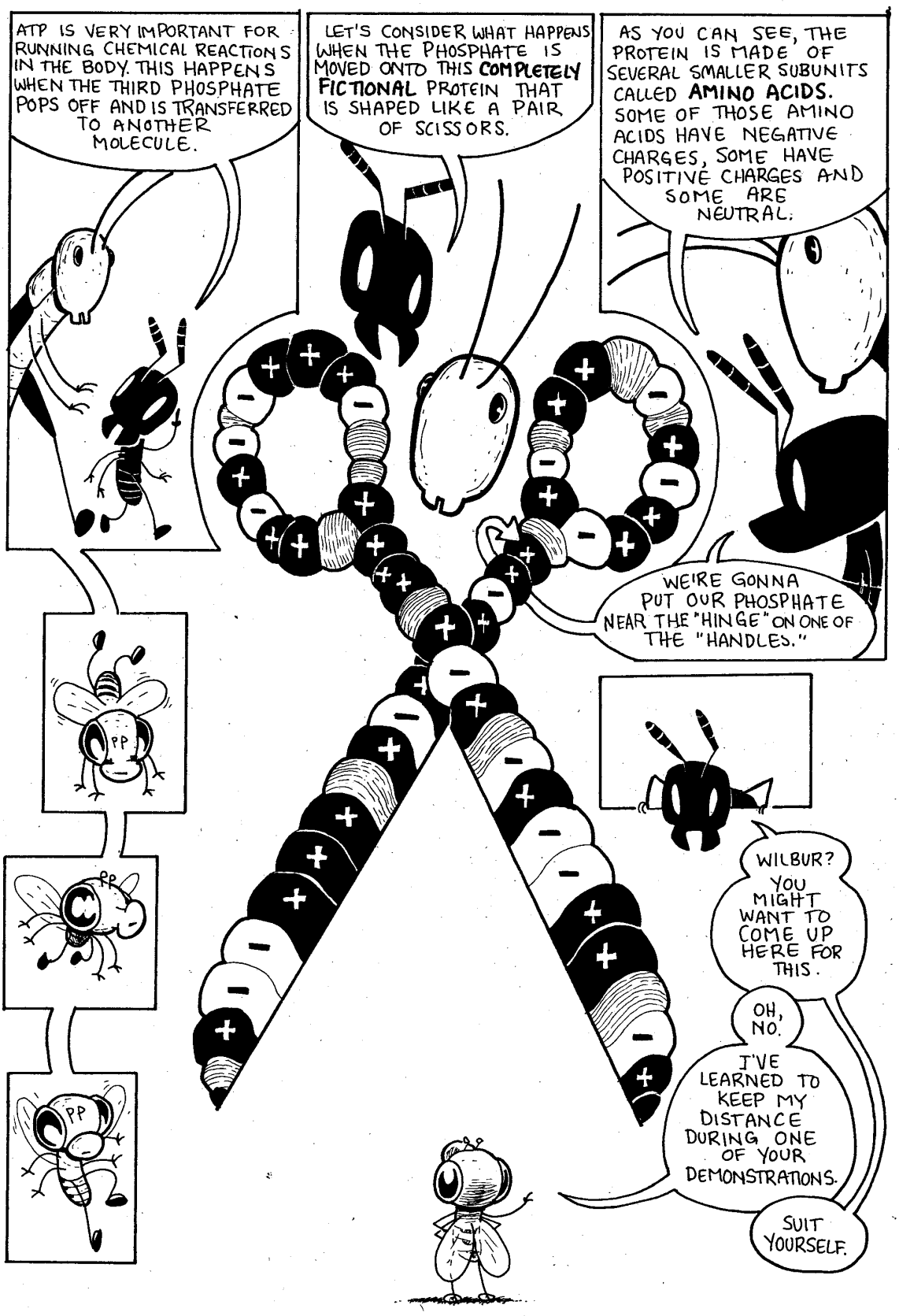

IT'S TRUE. PLUS, I WROTE IT IN ANCIENT SUMERIAN SO IT WAS EVEN MORE FUN THAN IT SOUNDS.
....

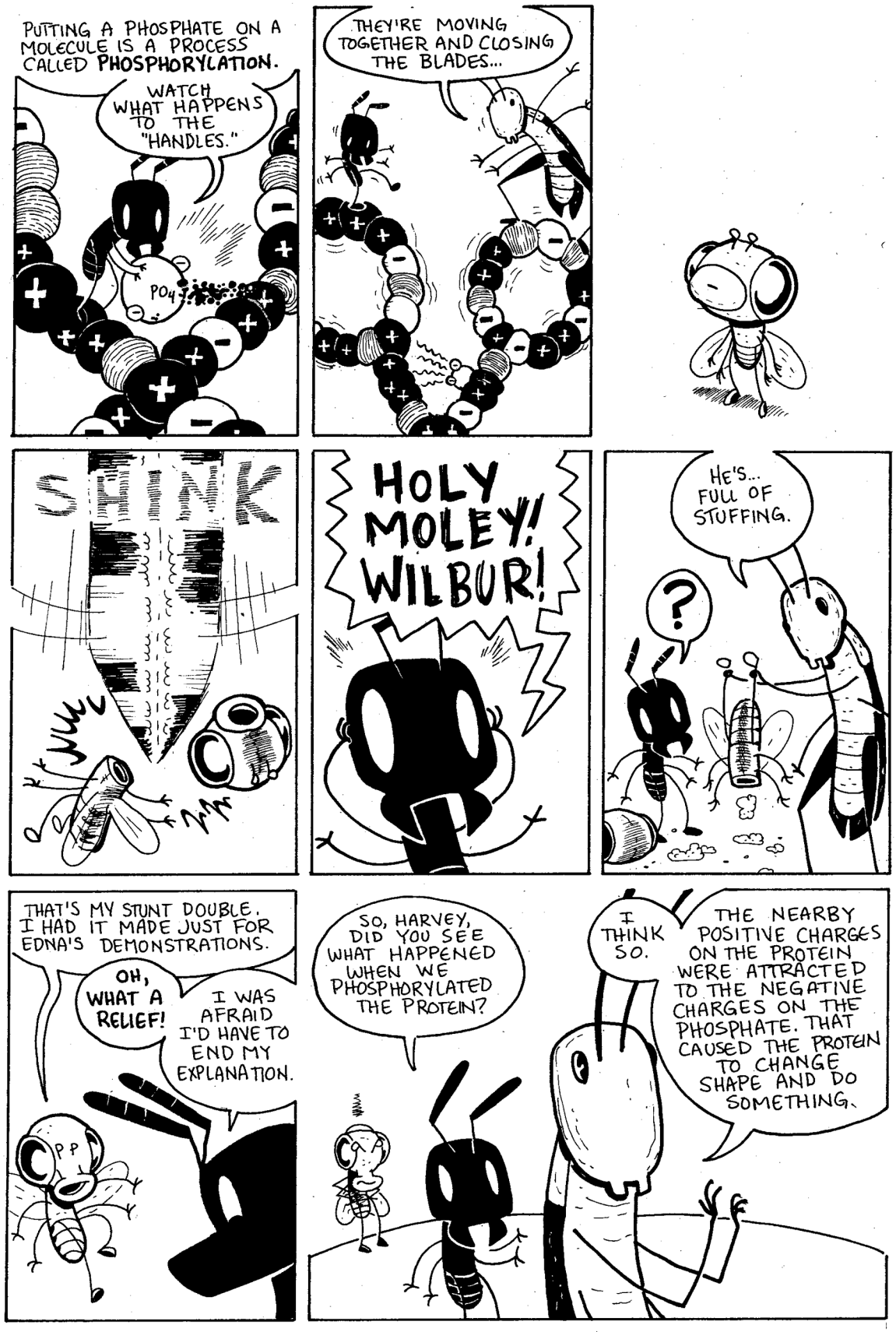

ATP IS A MOLECULE MADE BY ALL LIVING ORGANISMS. IT'S FULL NAME IS ADENOSINE TRIPHOSPHATE!
ATP

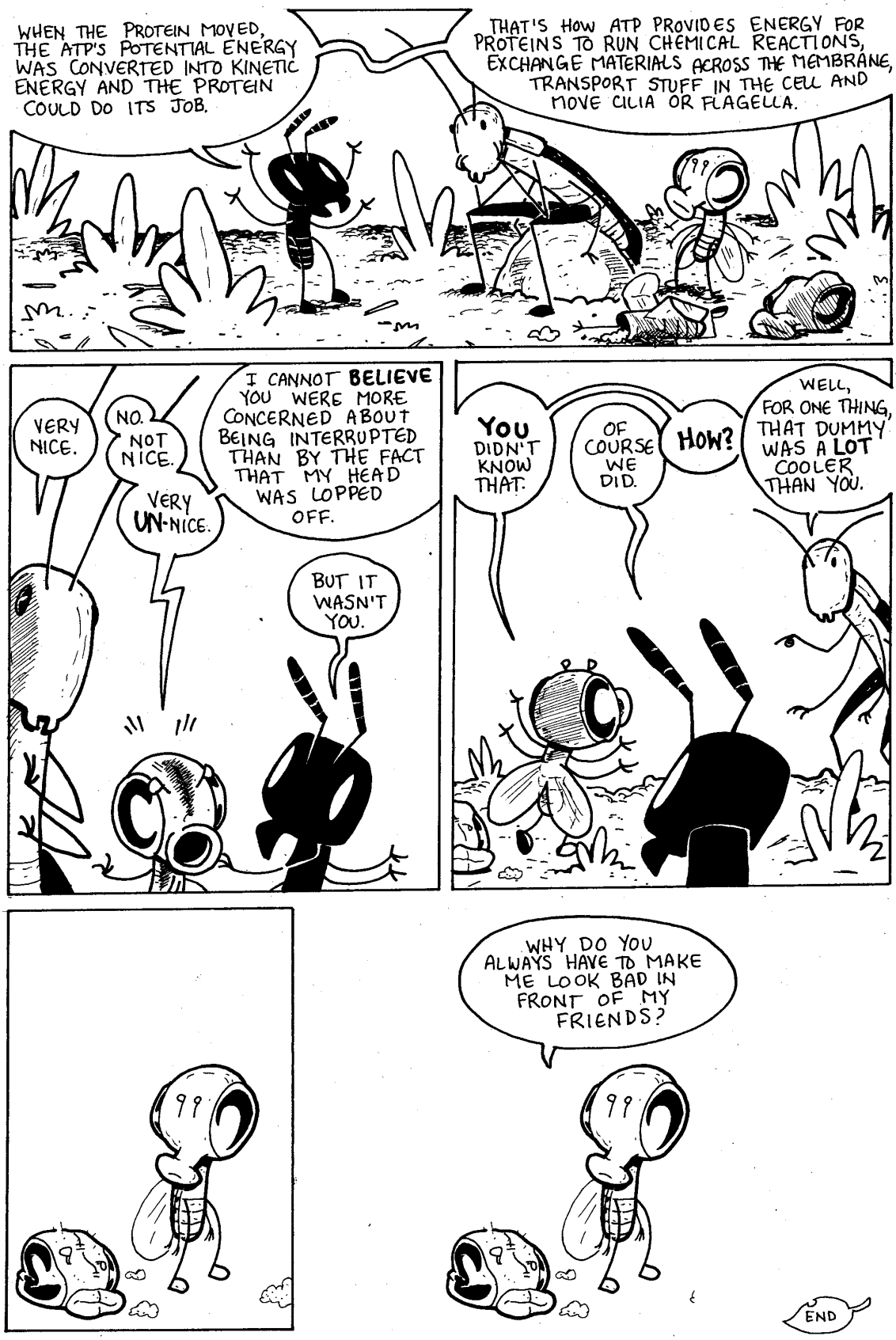

"TRI" TO REMEMBER THAT, HARVEY.
Shhh!
THE "TRI" IN THIS CASE REFERS TO THE THREE ENERGETIC PHOSPHATE GROUPS STUCK ON THE ADENOSINE MOLECULE.
ATP
PO4 PO4 PO4
3 Phosphate Groups
ADENOSINE MOLECULE
SO, THERE'S... ... ENERGY IN THESE THINGS?
YEP. LET ME SHOW YOU.
PO4 PO4 PO4
ATP IS MADE BY ADDING A SINGLE PHOSPHATE GROUP TO A MOLECULE OF ADENOSINE DIPHOSPHATE* (ALSO KNOWN AS ADP)
ADP
PO4 PO4
PO4
* THE "DI" MEANS THERE ARE ONLY 2 PHOSPHATE GROUPS
ADENOSINE MOLECULE
YOU HOLD THE PHOSPHATE, WILBUR. HOW MANY NEGATIVE CHARGES DOES IT HAVE?
TWO.
a negative charge
HOW MANY NEGATIVE CHARGES ON THE ADP PHOSPHATES, HARVEY?
I SEE THREE IN THE PANEL ABOVE.
GREAT. NOW, TRY TO PUSH THEM TOGETHER.


HARD..TO...
...PUSH..TOGETHER...
...INVISIBLE FORCE...
...REPELLING...
...HARVEY...
OOF!
PO4
PO4
PO4
...MUST...BE...
...YOUR...
...PERSONALITY...
ACTUALLY, IT'S THE "PERSONALITIES" OF THE PHOSPHATE GROUPS. WHEN WE CONSIDER THE ELECTRICAL FORCES BETWEEN MOLECULES, OPPOSITE CHARGES ATTRACT, BUT SIMILAR CHARGES REPEL EACH OTHER. IN THIS CASE, THE NEGATIVE CHARGES ON THE PHOSPHATES DO NOT WANT TO GO TOGETHER.
WHEW!
PP
CLICK
PO4
PO4
PO4
SHOO!
NICE WORK! THE ENERGY YOU USED TO PUSH THEM TOGETHER IS NOW TRAPPED IN THE CHEMICAL BOND YOU'VE MADE. WE CALL THAT ENERGY POTENTIAL ENERGY BECAUSE IT HAS THE POTENTIAL TO DO STUFF WHEN WE RELEASE IT LATER.
WAIT A MINUTE.. NONE OF THIS ADDS UP!
WHAT DO YOU~?
PP
THE NEGATIVE CHARGES!
I HAD 2 ON THE PHOSPHATE AND HARVEY HAD 3 ON THE ADP
EVERYBODY KNOWS THAT 2+3=6
5
RIGHT. 5
BUT THERE ARE ONLY 4 NEGATIVE CHARGES ON THE ATP!
PP


GOOD POINT. THE FIFTH NEGATIVE CHARGE WAS USED TO MAKE THE BOND HOLDING THEM TOGETHER.
O.K., BUT...
WHERE DOES THE ENERGY TO ASSEMBLE ATP COME FROM WHEN WILBUR AND I AREN'T HERE TO PUSH?
PO_4
PO_4
PO_4
IN ANIMALS LIKE US, ATP IS PUT TOGETHER USING ENERGY STORED IN THE FOOD WE EAT AND THAT ENERGY---
I'VE GOT THIS ONE, EDNA.
...AND THAT ENERGY COMES FROM GLUCOSE MOLECULES THAT ARE MADE DURING PHOTOSYNTHESIS.
SEE? I TOTALLY KNOW STUFF.
YEAH?
YOU DON'T HAPPEN TO KNOW WHEN TO SHUT-UP DO YOU?
SURE, I...
HEY!
THE THING ABOUT ATP IS THAT IT'S HARD TO KEEP ALL OF THOSE NEGATIVE CHARGES IN SUCH CLOSE PROXIMITY.
THOSE CHARGES ARE STILL REPELLING EACH OTHER AND THAT MAKES ATP HIGHLY REACTIVE.
SO, DOES THAT MEAN THE PHOSPHATE ON THE END POPS OFF PRETTY EASILY?
IT DOES.
IN FACT, THAT IS AN ESSENTIAL FEATURE OF HOW ATP WORKS.
C'MON, I'LL SHOW YOU.


ATP IS VERY IMPORTANT FOR RUNNING CHEMICAL REACTIONS IN THE BODY. THIS HAPPENS WHEN THE THIRD PHOSPHATE POPS OFF AND IS TRANSFERRED TO ANOTHER MOLECULE.
LET'S CONSIDER WHAT HAPPENS WHEN THE PHOSPHATE IS MOVED ONTO THIS COMPLETELY FICTIONAL PROTEIN THAT IS SHAPED LIKE A PAIR OF SCISSORS.
AS YOU CAN SEE, THE PROTEIN IS MADE OF SEVERAL SMALLER SUBUNITS CALLED AMINO ACIDS. SOME OF THOSE AMINO ACIDS HAVE NEGATIVE CHARGES, SOME HAVE POSITIVE CHARGES AND SOME ARE NEUTRAL.
WE'RE GONNA PUT OUR PHOSPHATE NEAR THE "HINGE" ON ONE OF THE "HANDLES."
PP
PP
PP
WILBUR? YOU MIGHT WANT TO COME UP HERE FOR THIS.
OH, NO.
I'VE LEARNED TO KEEP MY DISTANCE DURING ONE OF YOUR DEMONSTRATIONS.
SUIT YOURSELF.


PUTTING A PHOSPHATE ON A MOLECULE IS A PROCESS CALLED **PHOSPHORYLATION.**
WATCH WHAT HAPPENS TO THE "HANDLES."
PO4
THEY'RE MOVING TOGETHER AND CLOSING THE BLADES...
SHINK
HOLY MOLEY! WILBUR!
HE'S... FULL OF STUFFING.
?
THAT'S MY STUNT DOUBLE. I HAD IT MADE JUST FOR EDNA'S DEMONSTRATIONS.
OH, WHAT A RELIEF!
I WAS AFRAID I'D HAVE TO END MY EXPLANATION.
SO, HARVEY, DID YOU SEE WHAT HAPPENED WHEN WE PHOSPHORYLATED THE PROTEIN?
I THINK SO.
THE NEARBY POSITIVE CHARGES ON THE PROTEIN WERE ATTRACTED TO THE NEGATIVE CHARGES ON THE PHOSPHATE. THAT CAUSED THE PROTEIN TO CHANGE SHAPE AND DO SOMETHING.


WHEN THE PROTEIN MOVED, THE ATP'S POTENTIAL ENERGY WAS CONVERTED INTO KINETIC ENERGY AND THE PROTEIN COULD DO ITS JOB.
THAT'S HOW ATP PROVIDES ENERGY FOR PROTEINS TO RUN CHEMICAL REACTIONS, EXCHANGE MATERIALS ACROSS THE MEMBRANE, TRANSPORT STUFF IN THE CELL AND MOVE CILIA OR FLAGELLA.
VERY NICE.
NO. NOT NICE.
VERY UN-NICE.
I CANNOT BELIEVE YOU WERE MORE CONCERNED ABOUT BEING INTERRUPTED THAN BY THE FACT THAT MY HEAD WAS LOPPED OFF.
BUT IT WASN'T YOU.
YOU DIDN'T KNOW THAT.
OF COURSE WE DID.
HOW?
WELL, FOR ONE THING, THAT DUMMY WAS A LOT COOLER THAN YOU.
WHY DO YOU ALWAYS HAVE TO MAKE ME LOOK BAD IN FRONT OF MY FRIENDS?
END