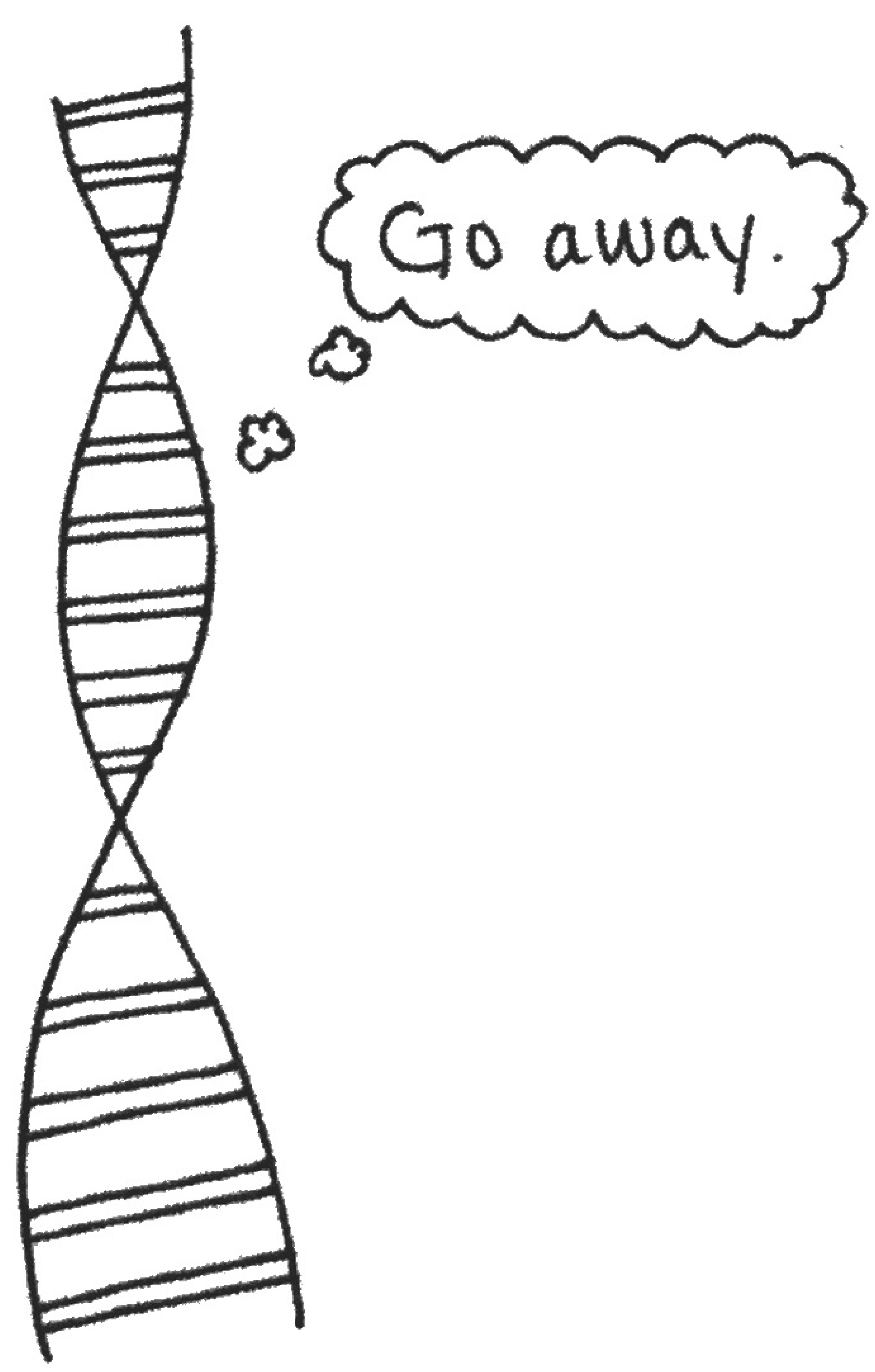
PART 1

# The Basics

# Your Friend, DNA

DNA isn't much of a showboat. It stays hidden away inside your cells, preferring to be left alone, keeping all its secrets. (Sounds a lot like my ideal vacation.) But sorry, DNA. We're going to be intruding on that personal space of yours, whether you like it or not.

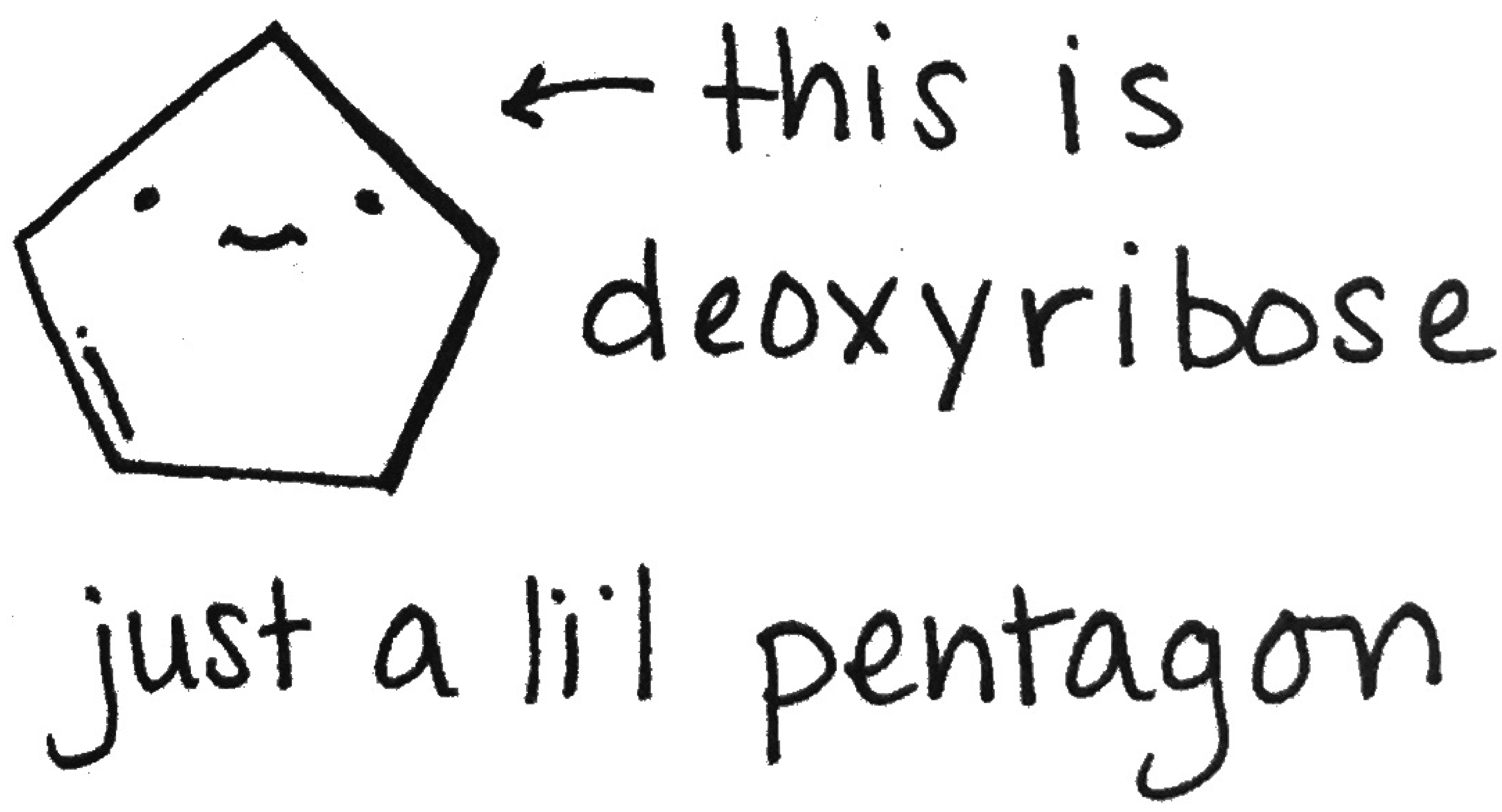



DNA is a useful acronym, because the full name is a bit of a mouthful: deoxyribonucleic acid. Yeah, I know. It's not a great name, but don't blame me. I wasn't around when it was named. I would have saved everyone a lot of time by naming it Reginald, or maybe Gladys. But this is the name we're stuck with. I know it looks daunting, but when you split it apart, it's not so bad.

**DNA:** An acronym for deoxyribonucleic acid, which is really boring stuff that is found in all of your cells and contains all the information for making you who you are. You know. No big deal.

*Deoxy* is just there to say that something has one less oxygen atom. What exactly has one less oxygen? The next part of the name, *ribo*. That's short for a sugar called *ribose*. So the whole first part, "de-oxy-ribo" just means that there is something in it called a ribose that's missing one oxygen atom. So far, so good.

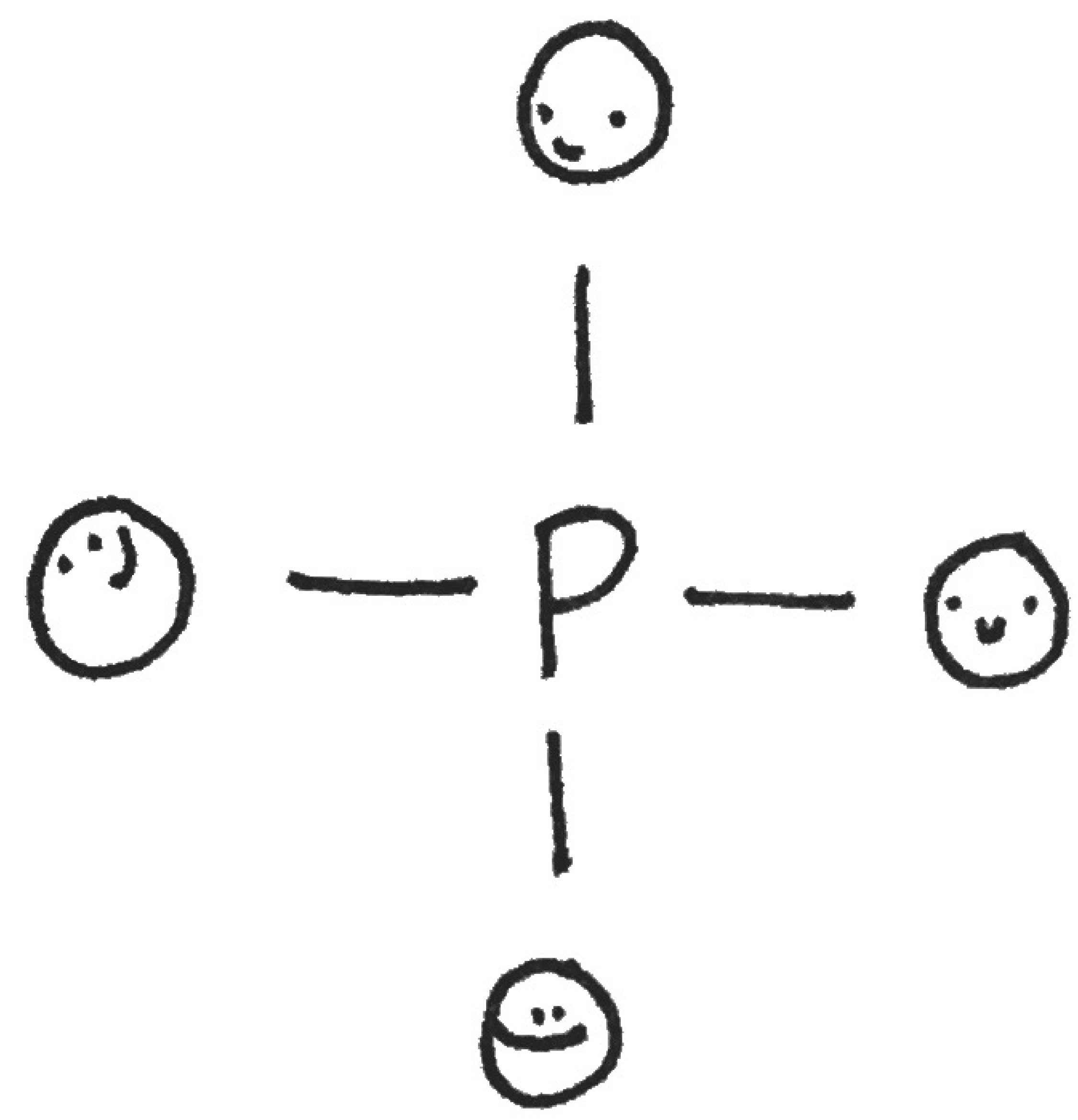
**Deoxyribose:** A pentagon-shaped sugar that is found in the backbone of DNA.




Now let's get to that ribose bit I mentioned. Ribose and deoxyribose are sugars. "-ose" is actually a very popular ending for various types of sugars. (Think of glucose, sucrose, and fructose.) Deoxyribose isn't nearly as popular as these other sugars, but it should be, since it's an important part of DNA. Deoxyribose is part of the backbone of DNA—the sides of the twisted ladder.

The other part of the backbone is something called a phosphate group. It's made of an atom of phosphorous and four atoms of oxygen. The sides of the DNA ladder are alternating phosphate groups and deoxyriboses. My word processor doesn't think that deoxyribose is a real word, but I'll have to assure it that it is.

**Phosphate:** A chemical compound that makes up part of the backbone of DNA. It is a phosphorous atom surrounded by four oxygen atoms.

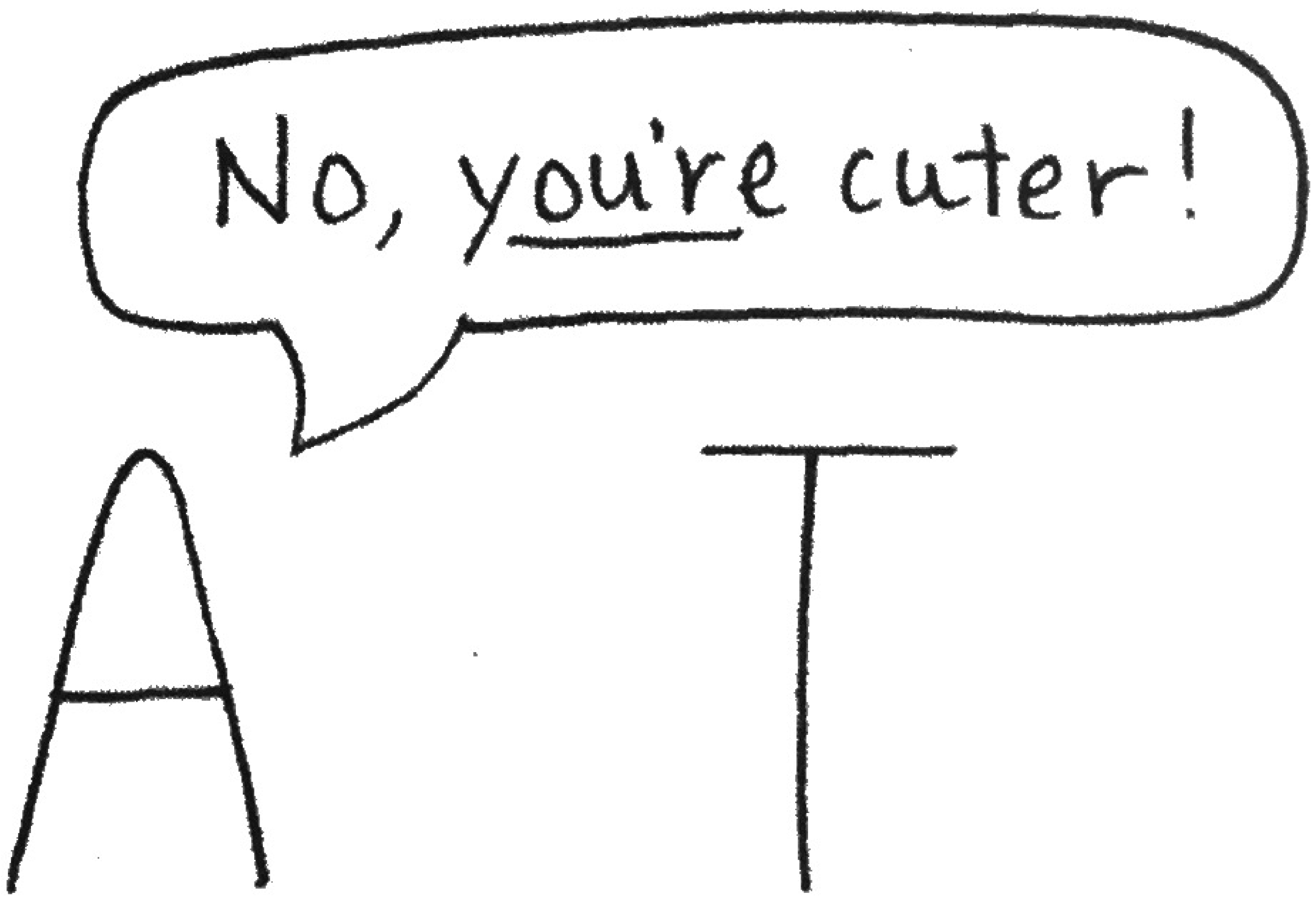



a phosphate group

But the backbone of sugar and phosphates is not exactly the fun part of DNA. The real business-doing portion of DNA is in the rungs of the ladder where the "bases" live. You may have heard of the bases of DNA before—they're those letters A, T, C, and G. Their full names are adenine, thymine, cytosine, and guanine. It's pairs of these guys that make the rungs of that DNA ladder. The bases are very particular about how they go about this: A pairs with T, C pairs with G. I heard that A can't stand to be around C, and G thinks T is an obnoxious brat. But you didn't hear that from me.

**Base:** The part of DNA that forms the rungs of the double helix ladder.

To describe the base pairs matching up just so, we say that they complement each other. If you read down one side of DNA and have TTAAGC, the complementary sequence would be AATTCG. Each base has a specific complement, which is not to be confused with bases compl*i*menting each other, which I'm sure they often do, but it has not yet been scientifically verified and published in a reputable journal. I'm still holding out hope, though.




**Adenine:** One of the bases in DNA that make up the rungs of the ladder. It pairs with thymine.

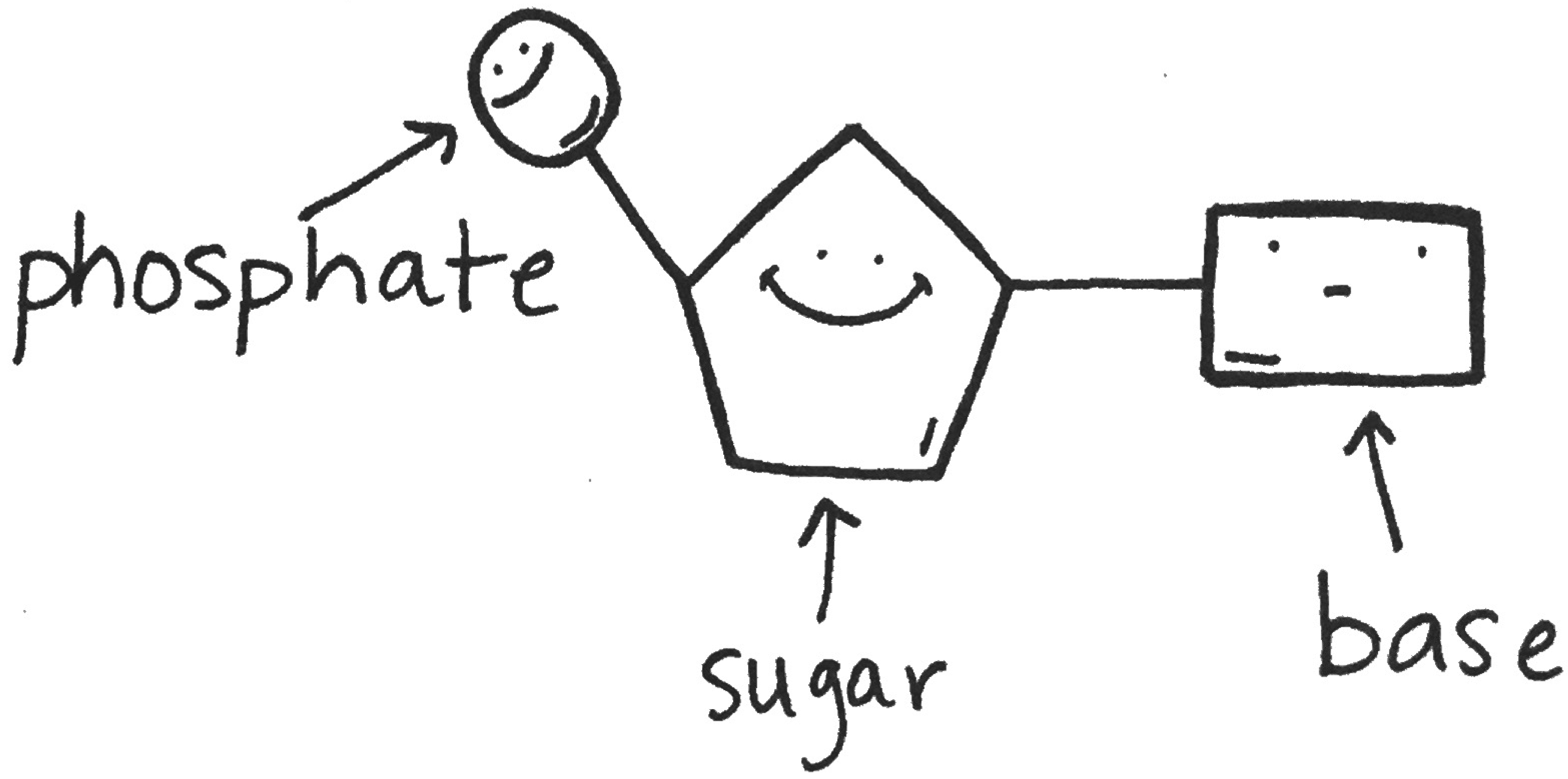
**Cytosine:** One of the bases in DNA that make up the rungs of the ladder. It pairs with guanine.

**Guanine:** One of the bases in DNA that make up the rungs of the ladder. It pairs with cytosine.

**Thymine:** One of the bases in DNA that make up the rungs of the ladder. It pairs with adenine.

To sum up: DNA is made of equal parts deoxyribose (that sassy sugar), phosphate groups (just a group of five atoms), and a base (A, T, C, or G). Together this unit is called a nucleotide. You'll notice *nuc* in lots of names. It seems scientists were smitten with the word *nucleus*, and since all of these things spend lots and lots of time in the nucleus of the cell, they just couldn't help but include it in the name.

BEHOLD! A nucleotide:




**Nucleotide:** The basic building block of DNA. It is made of a sugar, a phosphate, and a base.

When we talk about a sequence of DNA, we're not reading the base *pairs*, we're just talking about the order of the letters as you go along one side of the ladder. Here's an example of a DNA sequence:

ATGCCGCGCGTTTCGATATCGCTTTTCGCGAAAAAAAAA

Yup, that's what it all looks like. Pretty exciting, eh? Those four letters in random orders just going on and on like that. Your DNA is a very rambly book, about 3 billion letters long. If this book had 3 billion letters in it, it would be more than 60 million pages. And if that were the case, I wouldn't ever write it, as I would die from typing exhaustion. And old age. I'd also probably run out of things to say and just start smashing my forehead against my keyboard, and even if I did that for years I'd never finish. So . . . yeah, it's really long.

And remember, that 3-billion-letter instruction booklet of yours has just four letter varieties. Just take that in for a moment. Every bit of information in your DNA that makes you who you are—your tastes, your eye color, your obsession with ’80s romantic comedies—is expressed and stored with just four measly little letters.

In English, I’d run out of ATCG word combinations real fast. *At.* There’s one. *Cat.* On a roll here. *Tag.* Yeah, okay. I’m done with this. You win this one, DNA. But don’t let it go to your head.

# DNA, the Copycat

The twisted ladder shape of DNA, and the fact that the rungs are matched pairs of bases, isn't just for looks. This structure makes DNA very easy to copy, just like history homework. It's actually quite amazing. If someone took a page out of this book (and I sincerely hope no one feels the urge to do that), ripped it in half (again, please don't do this), and gave it to you, you wouldn't be able to get much out of it. With half the words missing, it would be rather useless as reading material. It might still be useful for paper airplanes, but not much else. But if DNA is ripped in half down the rungs of the ladders (which does happen), you can tell exactly what the other half of the strand would look like. This is a really handy feature.

One of the ways DNA actually makes use of this wonderful attribute is in DNA replication—when DNA makes more of itself. And replication is something DNA has to do frequently. Anytime your body has to make a new cell, it needs more DNA for that little baby cell.

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**Replication:** The process of DNA making a copy of itself.

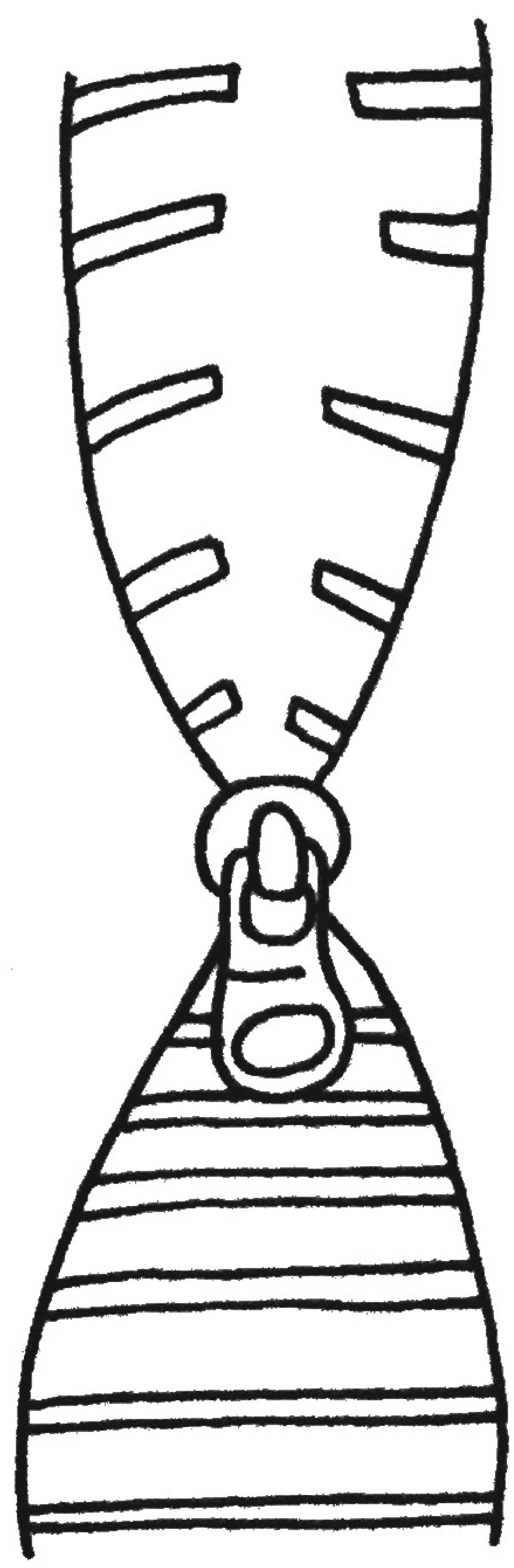
Your body is making new cells all the time. For example, think about your skin. You have a completely new coating of skin cells on your body every six weeks because you are constantly making more of them. And that means a lot of DNA replication is going on there.

In truth, the skin cells that you see when you look at your hand right now are all dead. The new skin cells are coming from below to replace the dead cells you're constantly shedding as you go through your day. Where do those dead cells go? See that bit of dust on your elliptical machine? That's where they went.

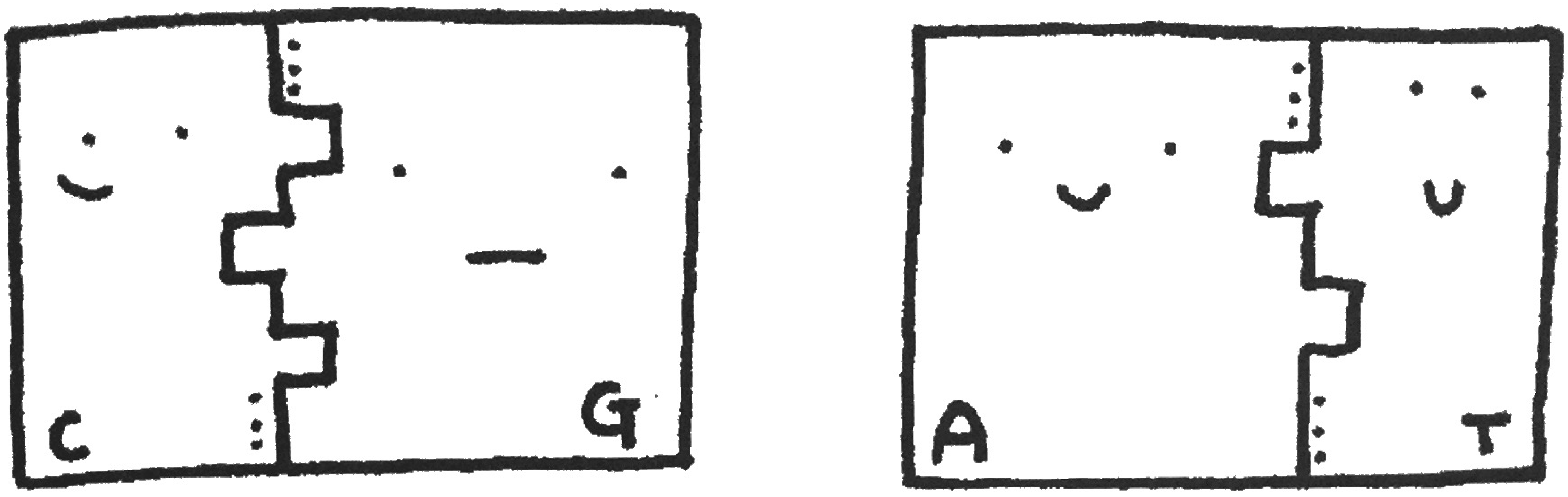
Dust: it's not just dirt and fly eggs, it's also your dead cells! Yummy!

DNA has to make an entire copy of itself before every cell divides so that all your new cells have a full set of "instructions." How DNA actually gets copied is a complex ballet of chemistry and chaos.

The DNA first has to be unzipped—which leads to many semi-clever jokes about genes (read as *jeans*) being "unzipped." Har har.

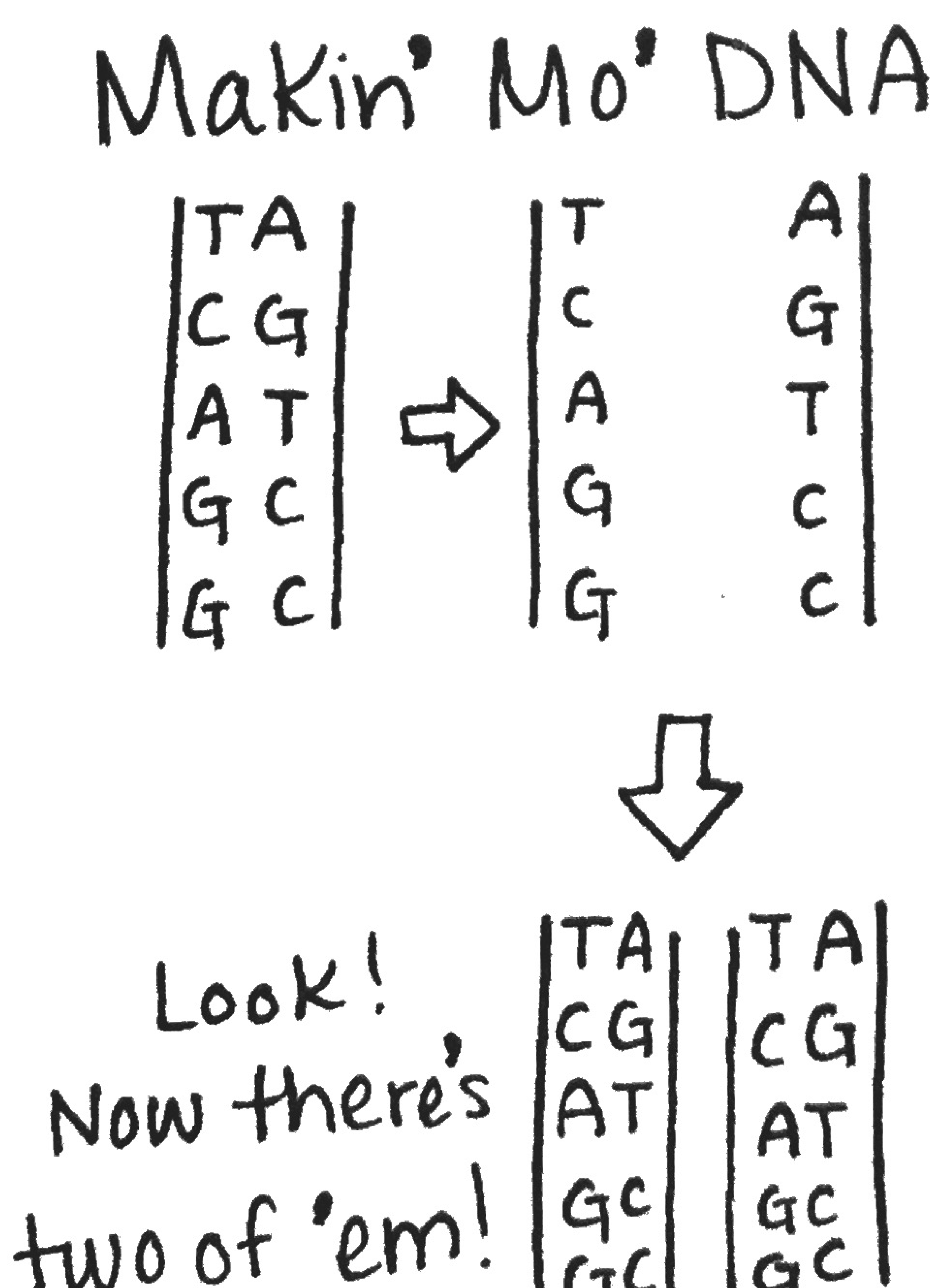


When it gets split down the middle, the bonds between the bases are broken, so you have the two sides of the DNA hanging out in the open, fully exposed like a molecular skinny dipper. To get two new full strands of DNA out of this unzipped, floppy one, nucleotides that are just floating around swoop in to be paired up correctly with the lonely bases there. Adenines are connected to thymines; cytosines are paired with guanines.




In biology class, these floaters are called "free nucleotides." They're "free" because they're not attached to anything, but they also cost zero dollars, so they are in many ways free nucleotides. I bet they don't wear underwear or bras either.

Now that all the new nucleotides have been matched up, you have two complete strands of DNA, where there used to just be one.



During replication, you can also see the other bonus of DNA's strand-y, ladder-y structure. These two new strands are made of half of an old strand and half of a new strand. This is clever because it provides insurance against mistakes, as using the original as a template makes it far more likely that you matched up the bases correctly. It doesn't always work out, though. Even with 99.99999 percent accuracy, when there are so many bases in your entire set of DNA, you are going to wind up with some mismatches and mistakes. That's one reason that your body has proteins that scan the DNA looking for typos to fix. But with 3 billion letters to look at (actually, double that if you think about both sides of the DNA), there are bound to be some oopsies.

In addition, your DNA can only be copied so many times before it starts to look a little old and tired. Just like making a photocopy of a photocopy of a photocopy, the quality starts to degrade. Some of a body's changes during the aging process are due to mistakes in DNA replication and the shortening of the DNA strands. Every time DNA is copied, a tiny bit on the end gets lopped off. To protect against this, DNA strands have protective caps on them called telomeres. But after years and years of replicating, those buffers are slowly eaten away, and then you're out of luck.

If our lifespan is partly determined by our DNA getting "old" as it gets copied over and over, what about species that live seemingly forever?

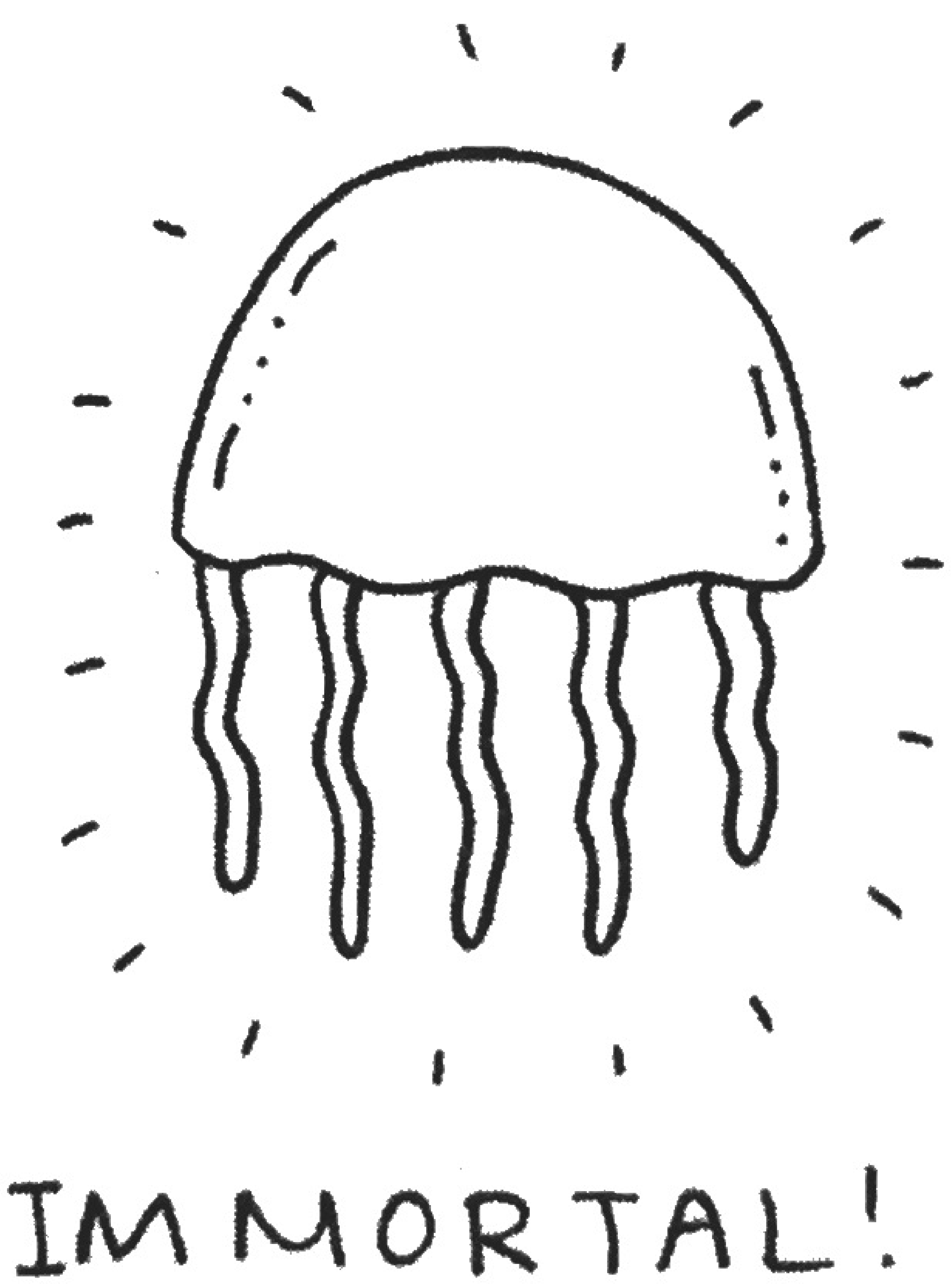
Have you heard of the "immortal jellyfish"? (First of all, before you get angry about fishes of jelly, I know it's not a fish, and that the better term is just *jelly*, but *immortal jelly* sounds like a menu item at a New Age restaurant, or a euphemism for a sex act, so I used my editorial powers and went with "jellyfish." It's also just more satisfying to say.)

These immortal jellies of fish of the sea appear to be immortal, and not simply because they haven't been observed dying of old age.

After they mature, they start to age in reverse, reverting back to the baby form of a jellyfish, which is a polyp.

Polyps are stationary little blobs that rest on the sea floor and look a little bit like anemones. The jellyfish you picture as the bell with dangling tentacles, gracefully floating in the ocean, is called the medusa stage of their life cycle.

These immortal jellies go forward and backward developmentally, going from baby to adults, back to baby, and repeat. It's like Benjamin Button, except it keeps cycling through.




How are they doing this? How does their DNA not show signs of wear and tear as these life cycles are played out again and again and again? We're working on figuring that out. And by "we" I mean the royal science "we," as in people who have nothing whatsoever to do with me.

Now that you know what DNA is and how it wound up in every one of your cells, we need to get to the more important stuff, like what the hell it does.