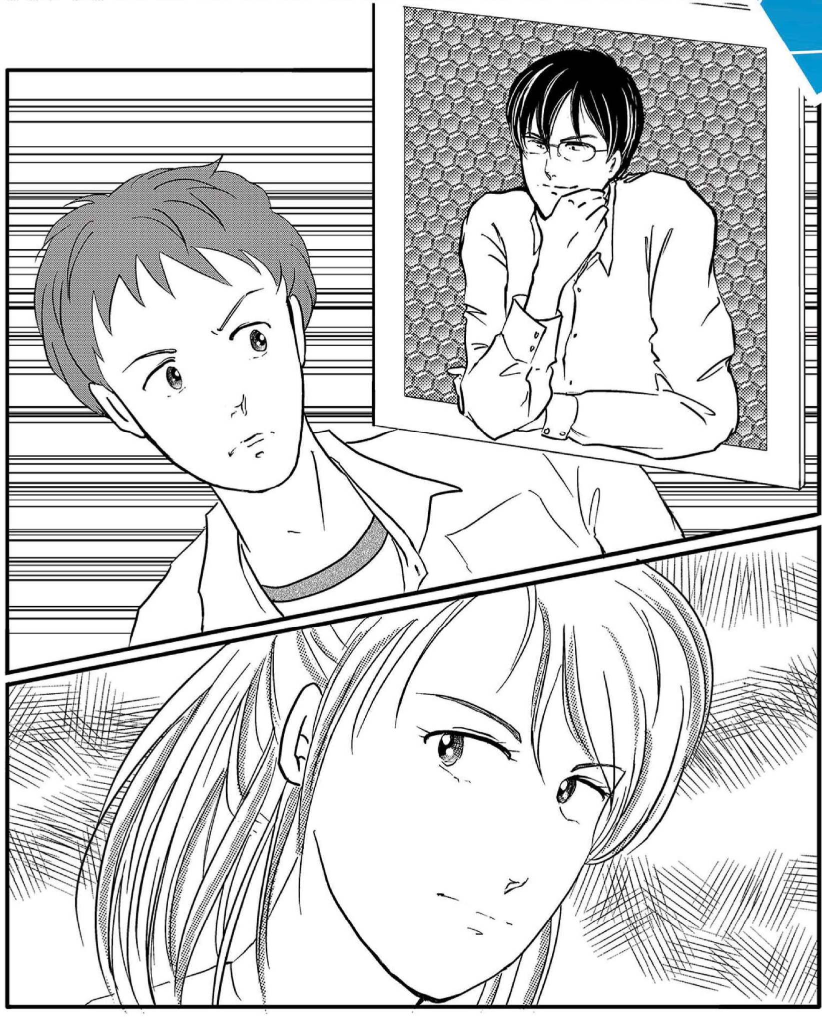
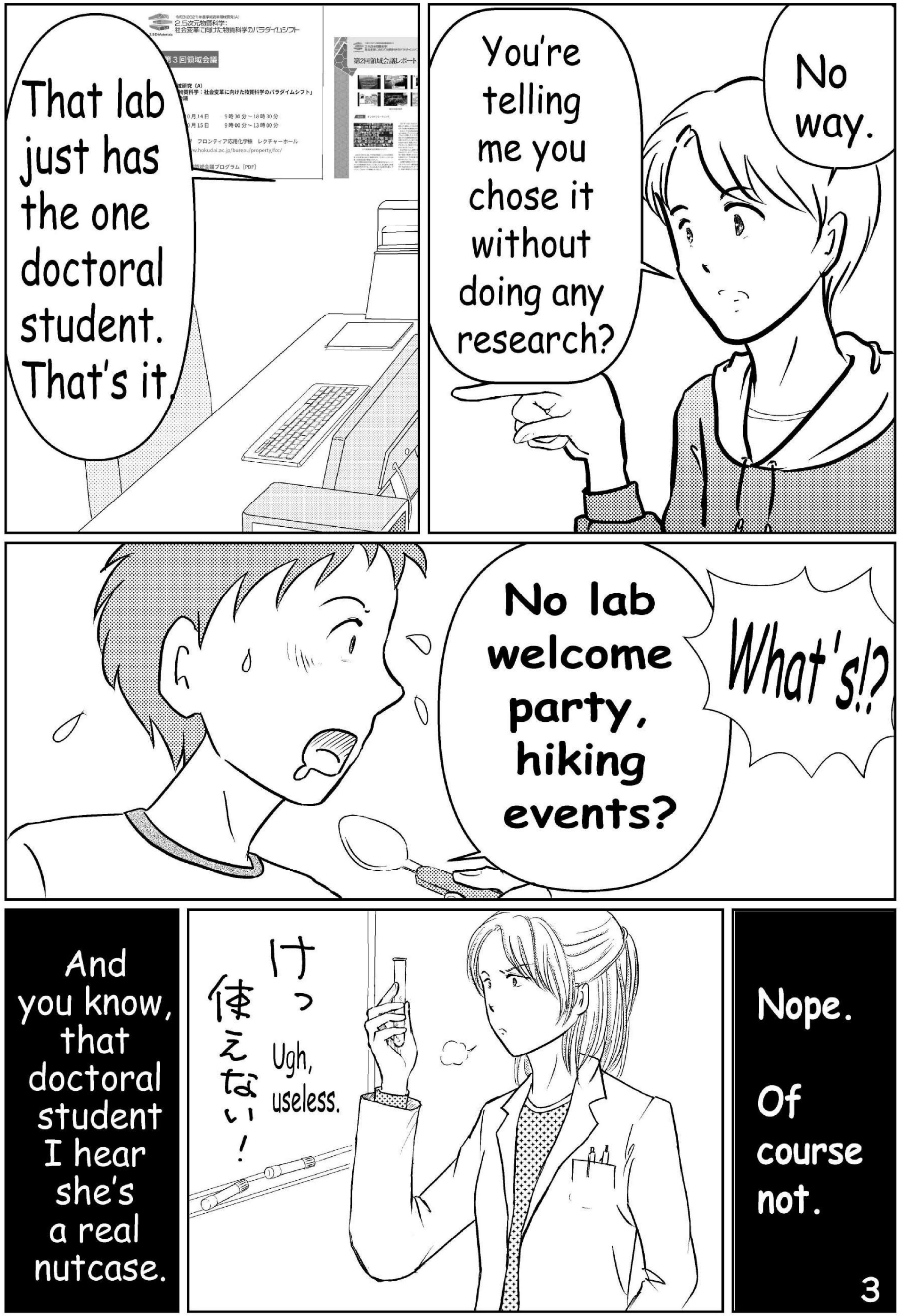
Chapter One: The Uninvited Senior Thesis Student

NEWS LETTER
令和3(2021)年度学術変革領域研究(A)
2.5次元物質科学：
社会変革に向けた物質科学のパラダイムシフト
2.5D Materials

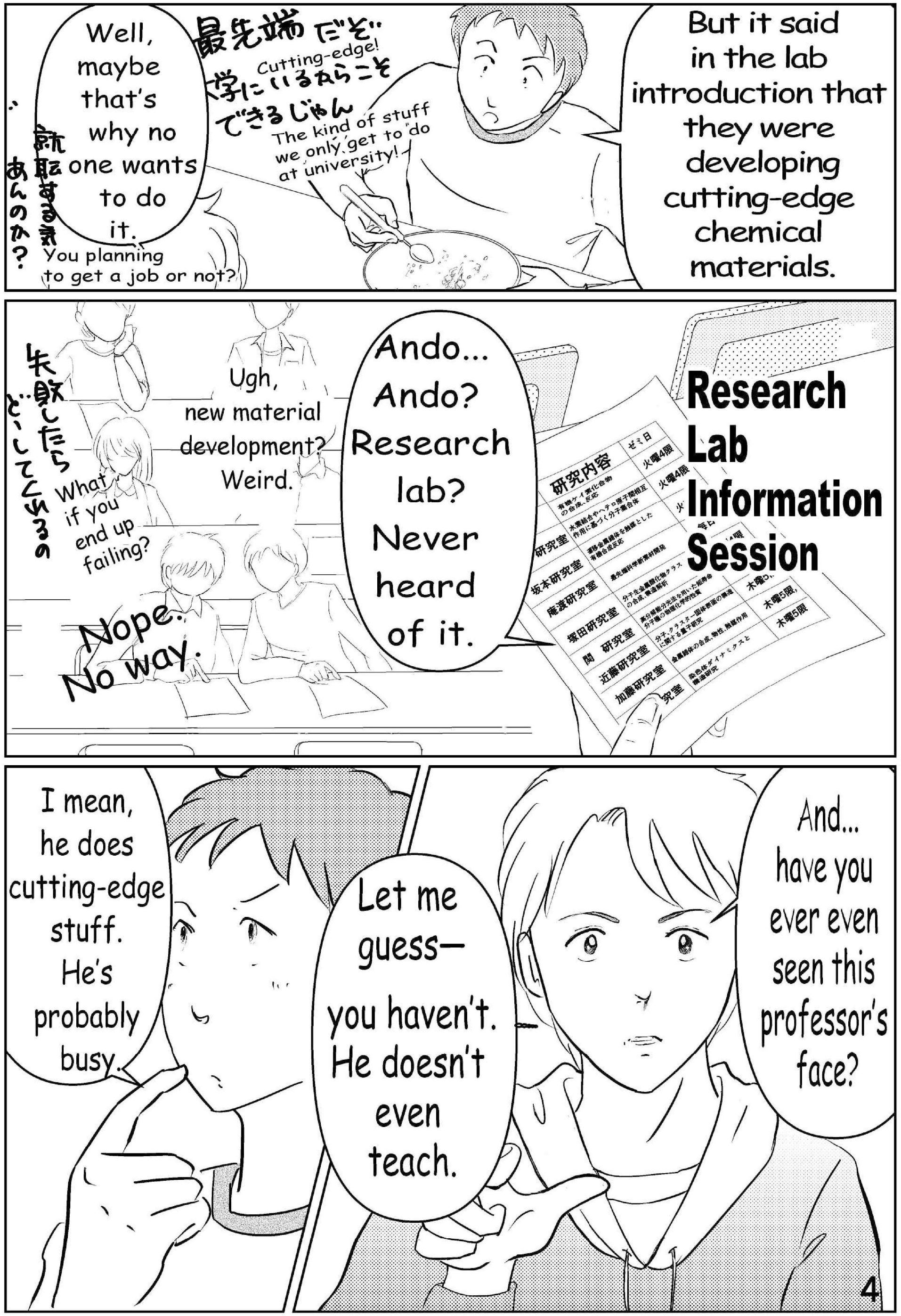
Welcome to the 2.5 D Laboratory



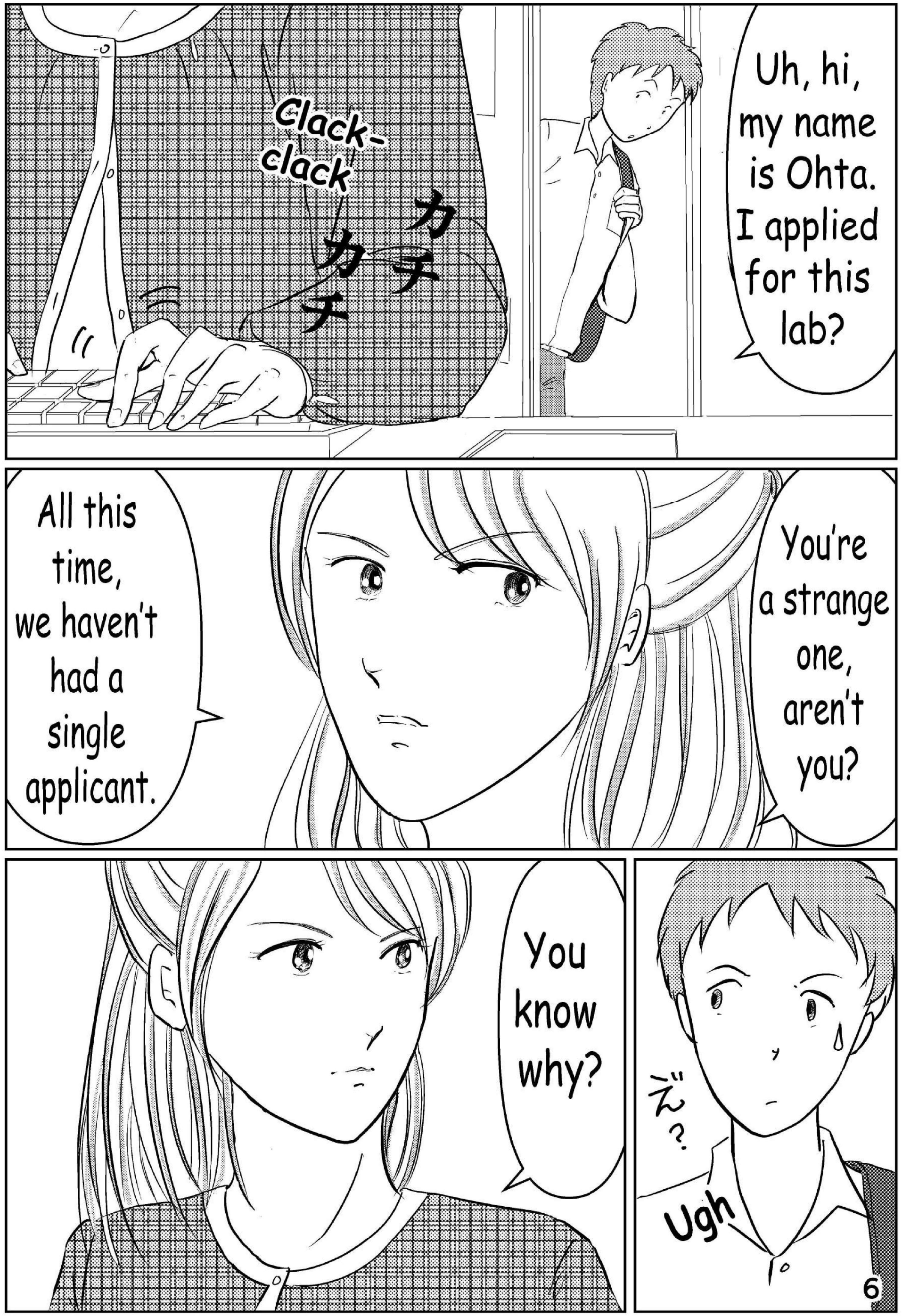
Companies are interested in materials that already **have** a future not new materials they don't even know if they'll be able to use.
I mean sure, but that's just not interesting to me.
In the study...
やっぱ夢がなきゃ
There should be dreams
And you know for the past couple years,
that lab has had **zero** applicants?
Huh?
B-But what about ?
...Or the others?

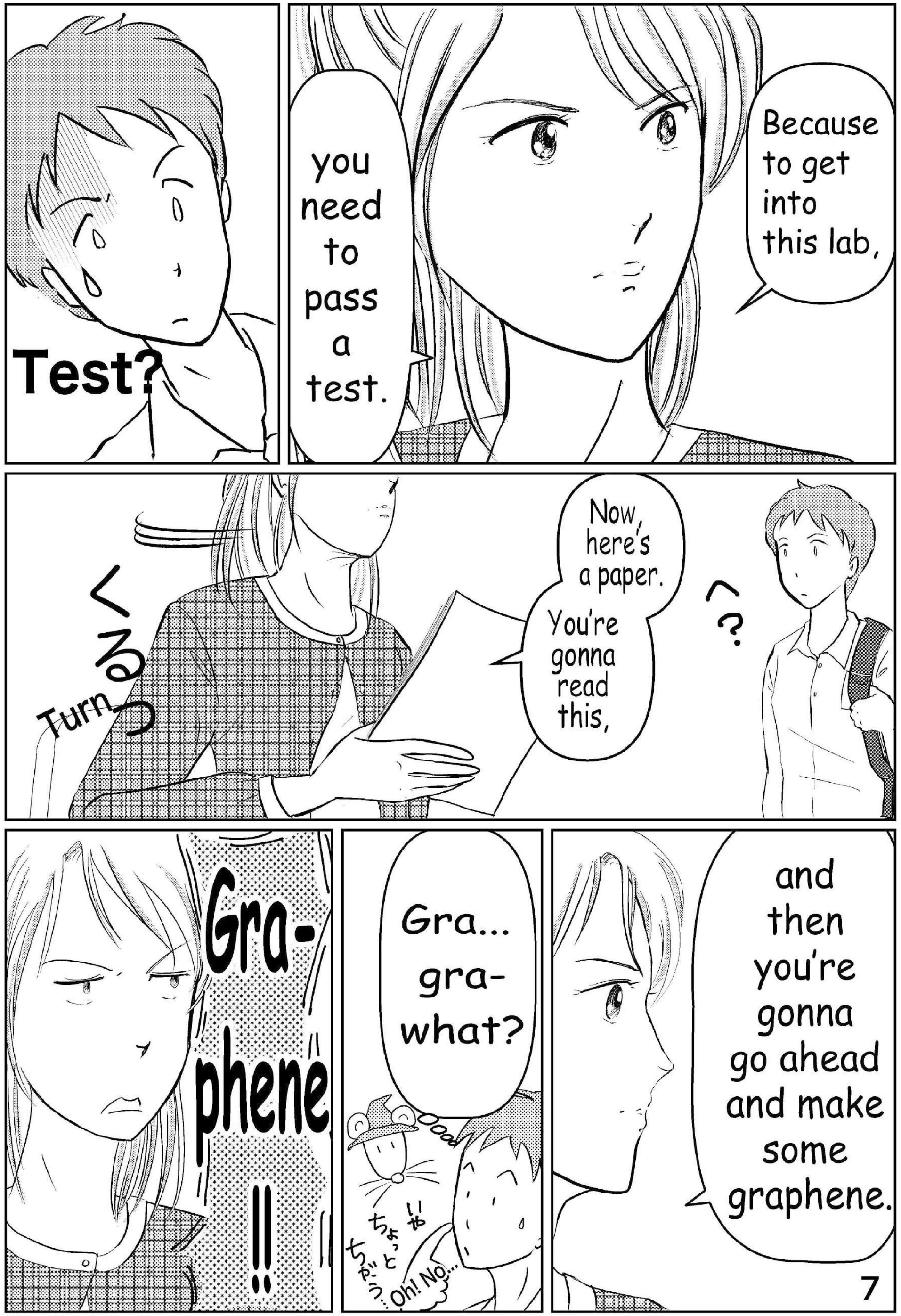


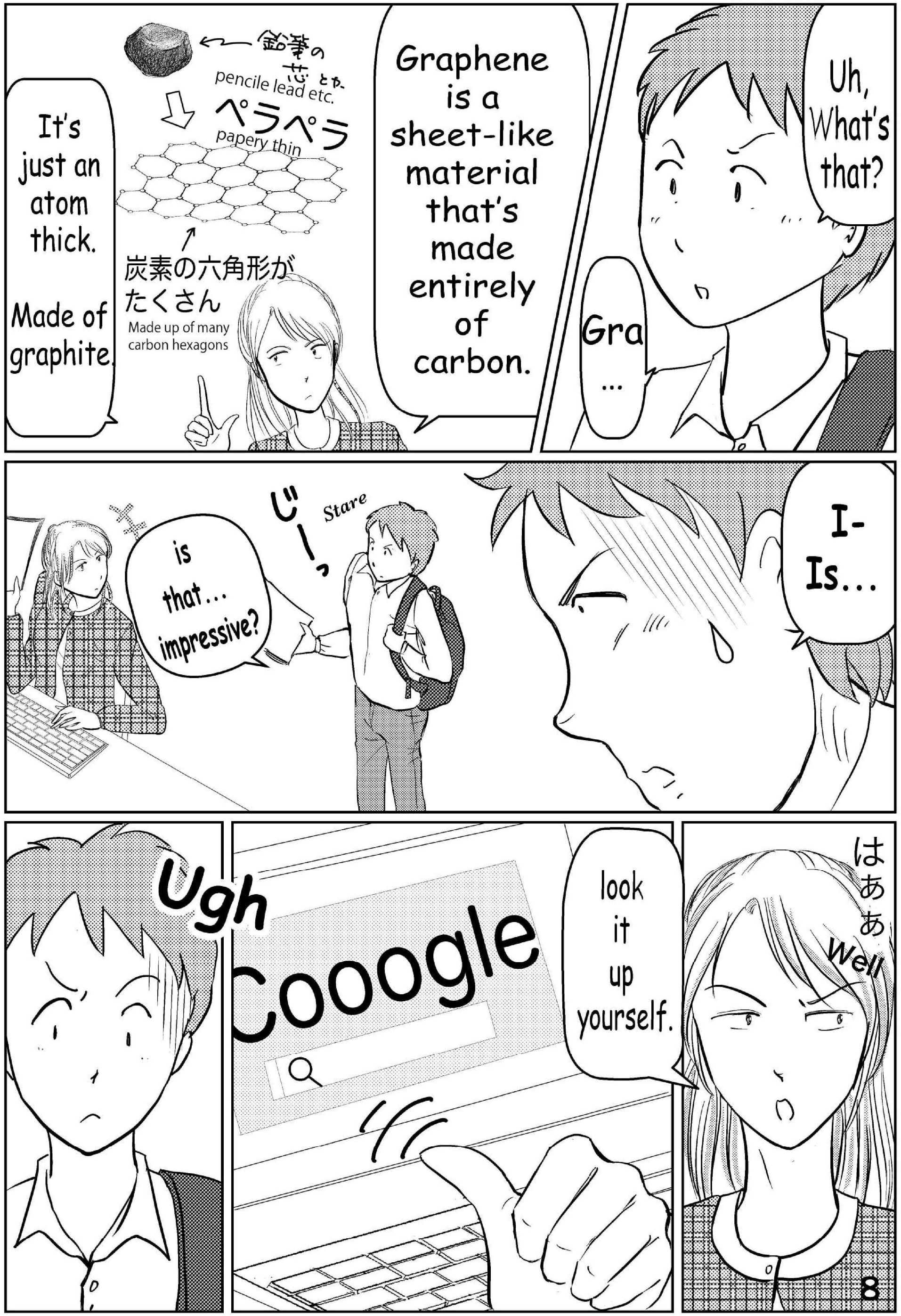
No way.
You're telling me you chose it without doing any research?
That lab just has the one doctoral student. That's it.
What's!?
No lab welcome party, hiking events?
Nope.
Of course not.
けっ
使えない！
Ugh, useless.
And you know, that doctoral student I hear she's a real nutcase.

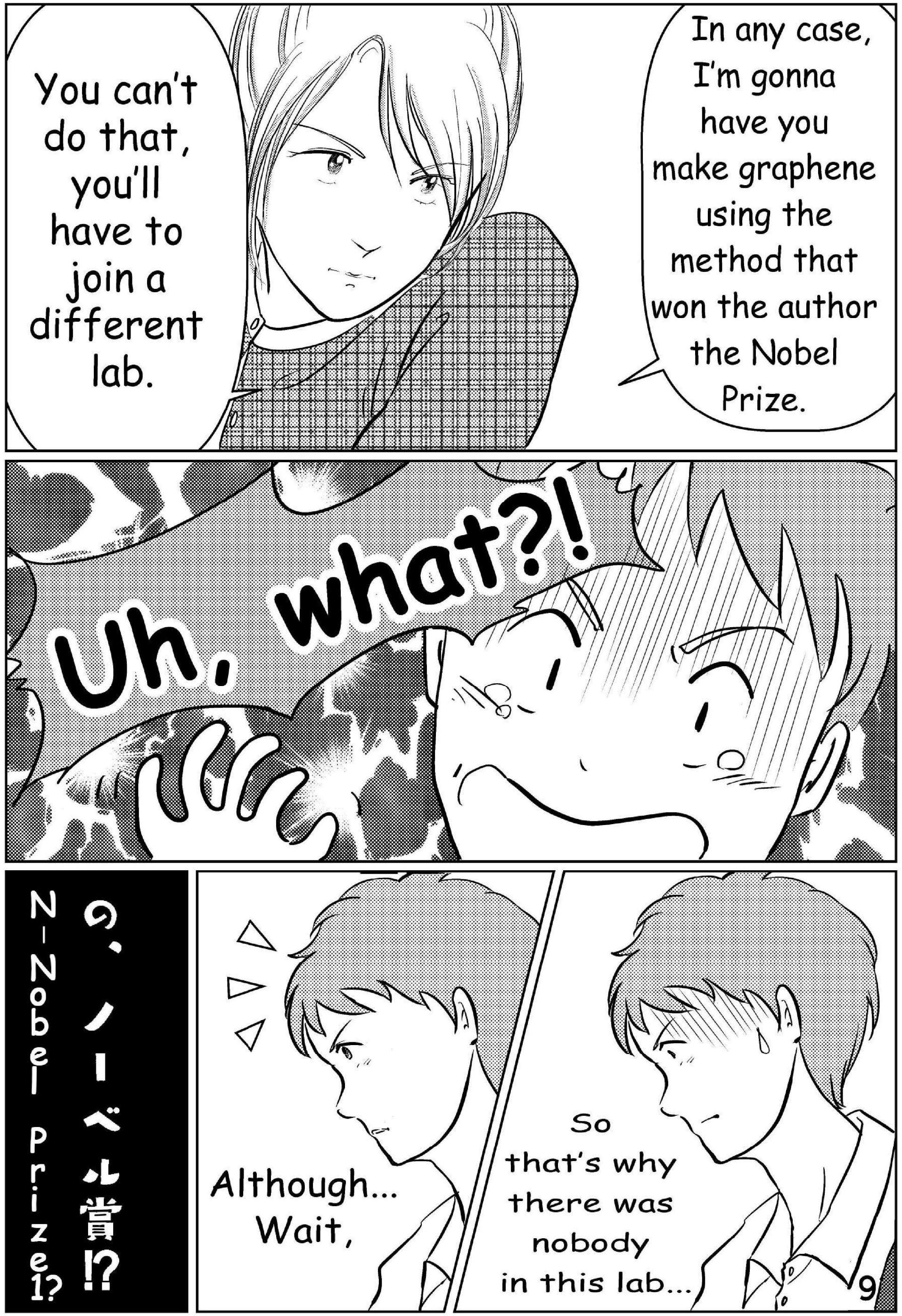

But it said in the lab introduction that they were developing cutting-edge chemical materials.
最先端だぞ
Cutting-edge!
大学にいるならこそできるじゃん
The kind of stuff we only get to do at university!
Well, maybe that's why no one wants to do it.
就職する気あんのか?
You planning to get a job or not?
Research Lab Information Session
Ando... Ando? Research lab? Never heard of it.
Ugh, new material development? Weird.
失敗したらどーしてくれるの
What if you end up failing?
Nope. No way.
And... have you ever even seen this professor's face?
Let me guess— you haven't. He doesn't even teach.
I mean, he does cutting-edge stuff. He's probably busy.


I want to do something incredible... Something I can only do right now, but...
Ah, maybe I messed up.
I wonder if there's a cooling-off period for labs?
理学B
理学D
Wait... What's gonna happen at these seminars?
うわぁーどーしよ
No way
Am I gonna be the only one there?
Am I gonna get destroyed by questions every session?
Day of Ando Research Lab visit
Turn
Hello~


Clack-clack
カチカチ
Uh, hi, my name is Ohta. I applied for this lab?
You're a strange one, aren't you?
All this time, we haven't had a single applicant.
You know why?
えっ?
Ugh
6

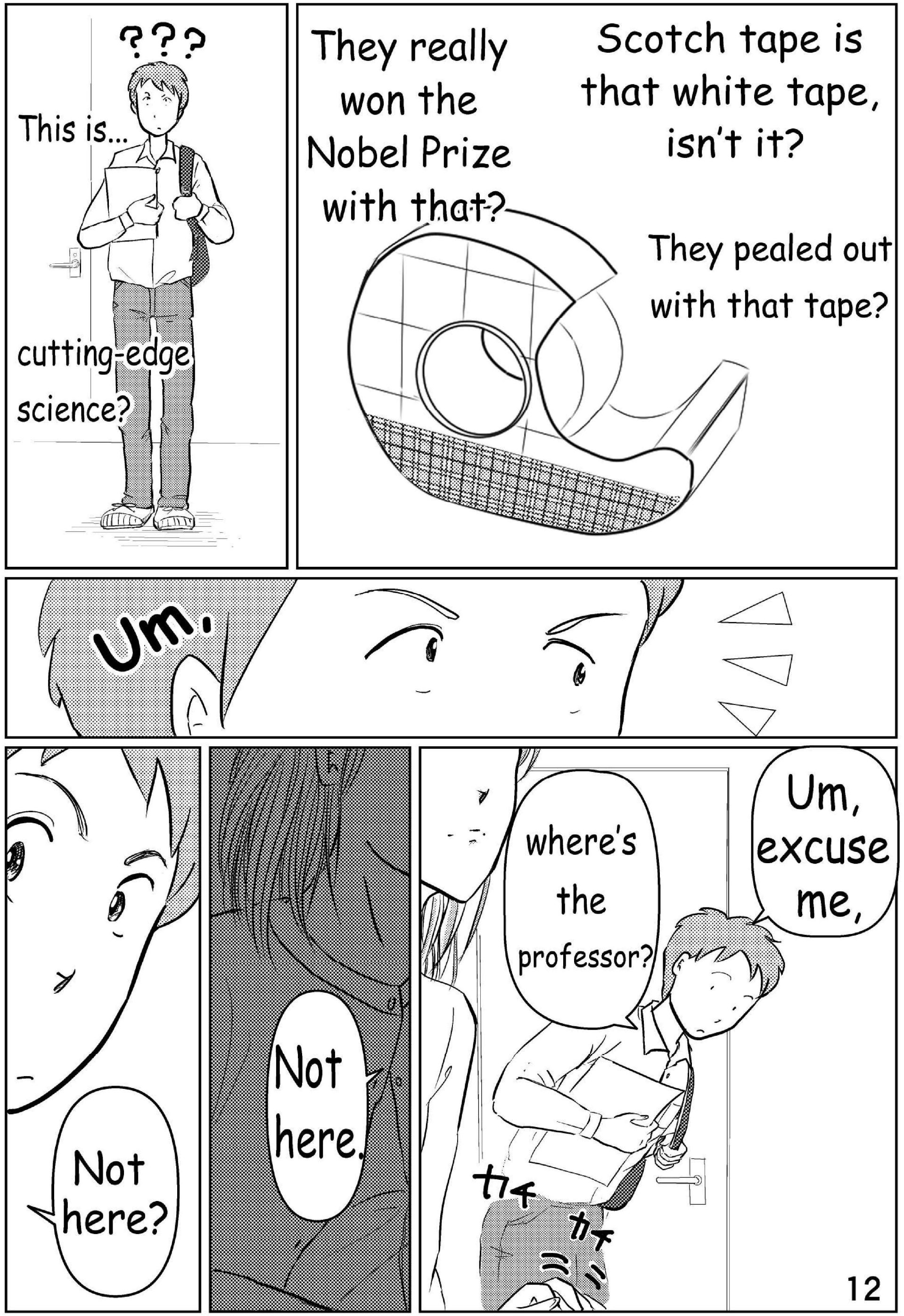

Because to get into this lab,
you need to pass a test.
Test?
Now, here's a paper.
You're gonna read this,
くるっ
Turn
へ?
and then you're gonna go ahead and make some graphene.
Gra... gra-what?
いや ちょっと ちがう…
Oh! No...
Gra-phene!!
7

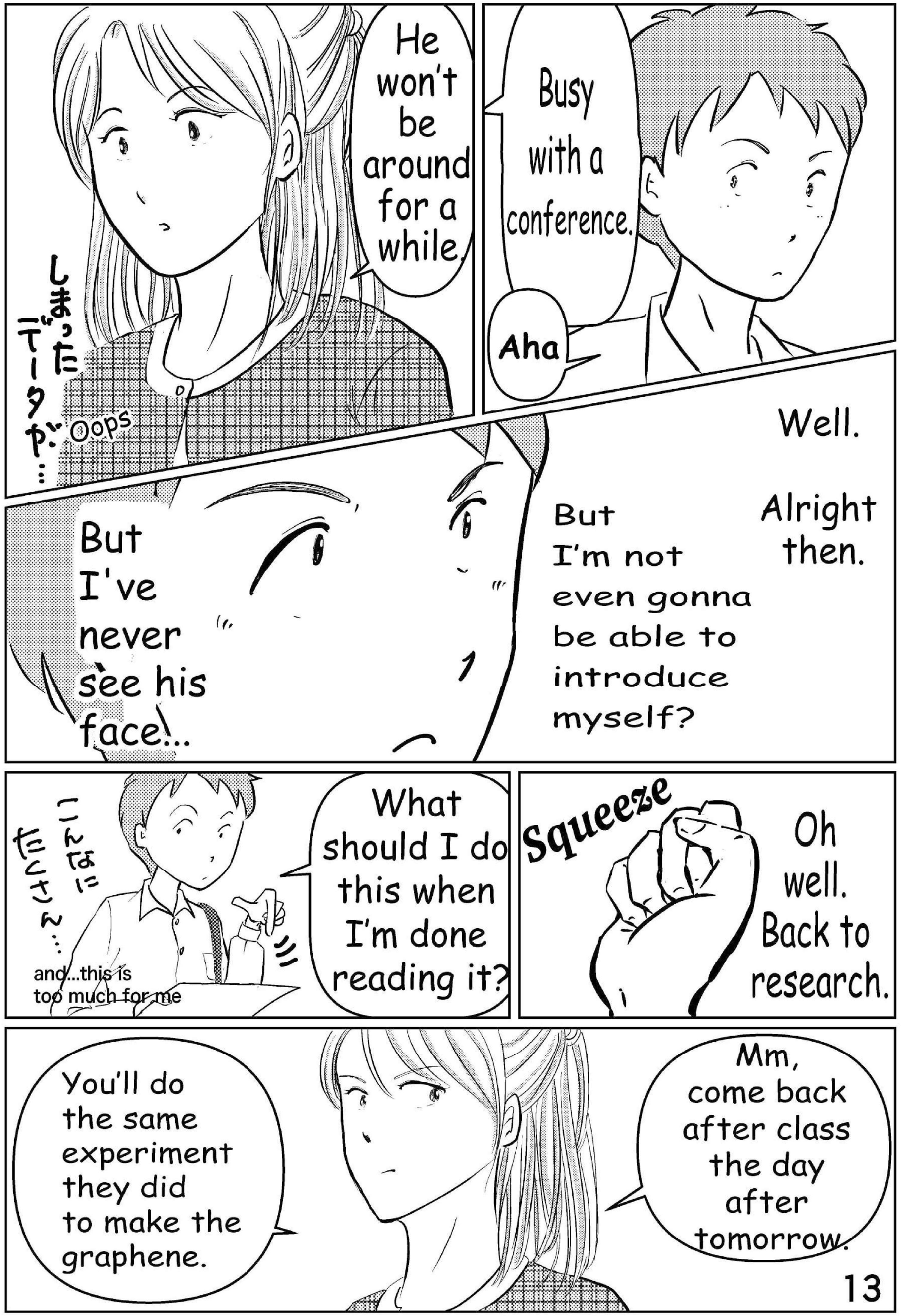

Uh, What's that?
Gra ...
Graphene is a sheet-like material that's made entirely of carbon.
鉛筆の芯とか
pencile lead etc.
ペラペラ
papery thin
炭素の六角形がたくさん
Made up of many carbon hexagons
It's just an atom thick.
Made of graphite.
I- Is...
じーっ
Stare
is that... impressive?
はああ
Well
look it up yourself.
Cooogle
Ugh
8

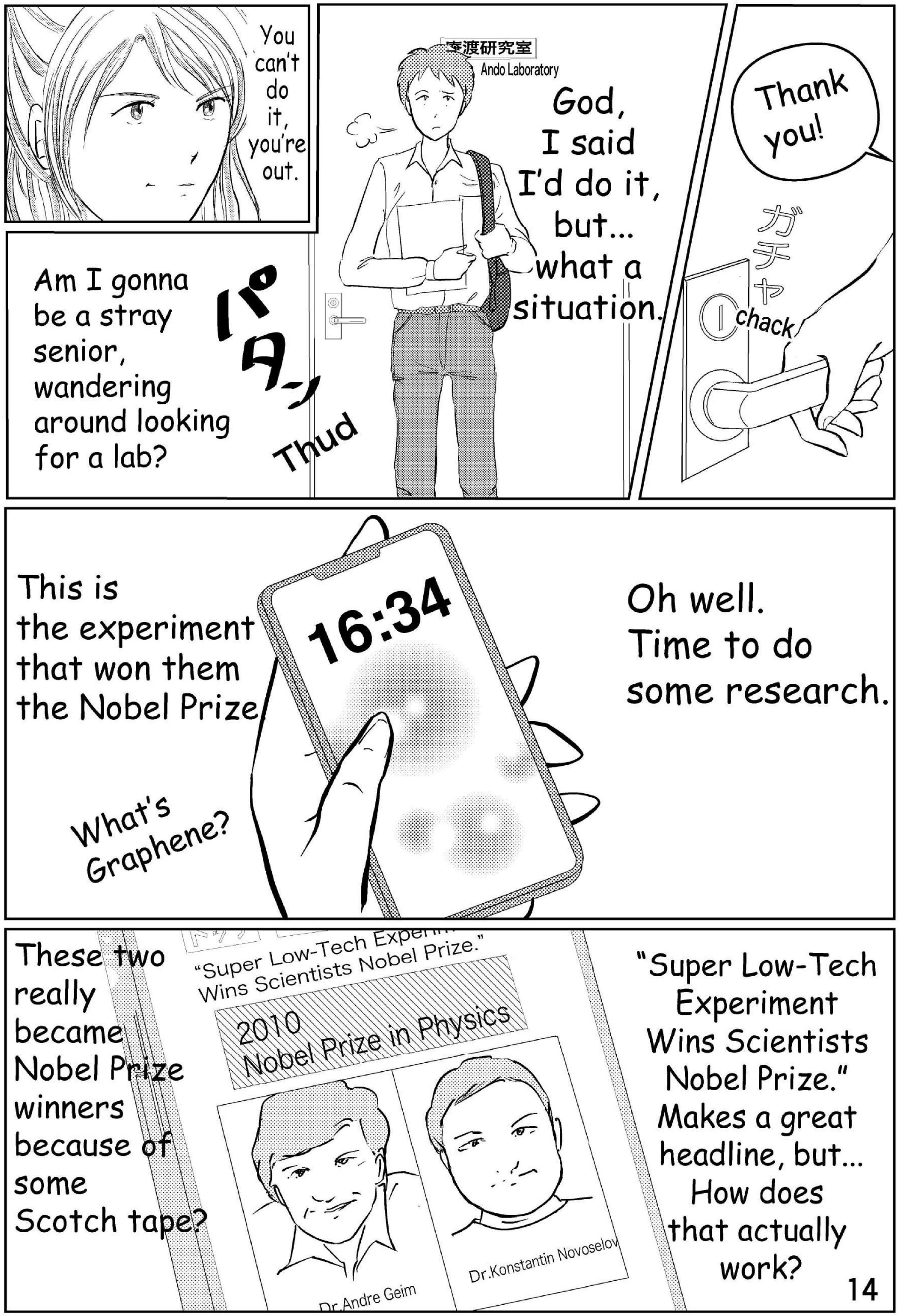

In any case, I'm gonna have you make graphene using the method that won the author the Nobel Prize.
You can't do that, you'll have to join a different lab.
Uh, what?!
So that's why there was nobody in this lab...
Although... Wait,
の、ノーベル賞!?
N-Nobel Prize!?
9

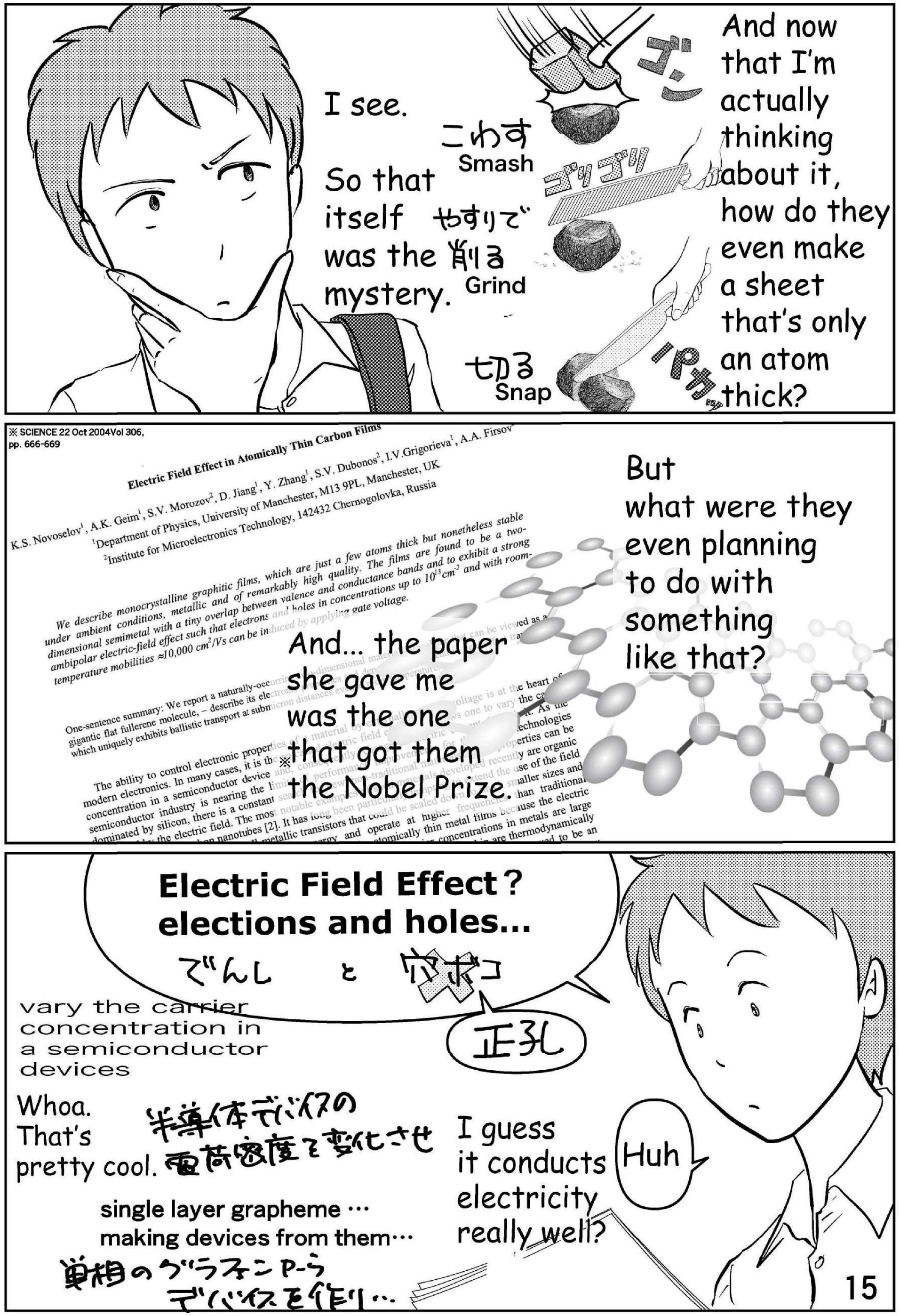

I'll do it!
I'll do it!
の〜べる
Nobel
. . .
You can't do it, you're out.
the Nobel
KUNGL. VETENSKAPS AKADEMIEN
Graphene - one-atomic-layer thick 2D material

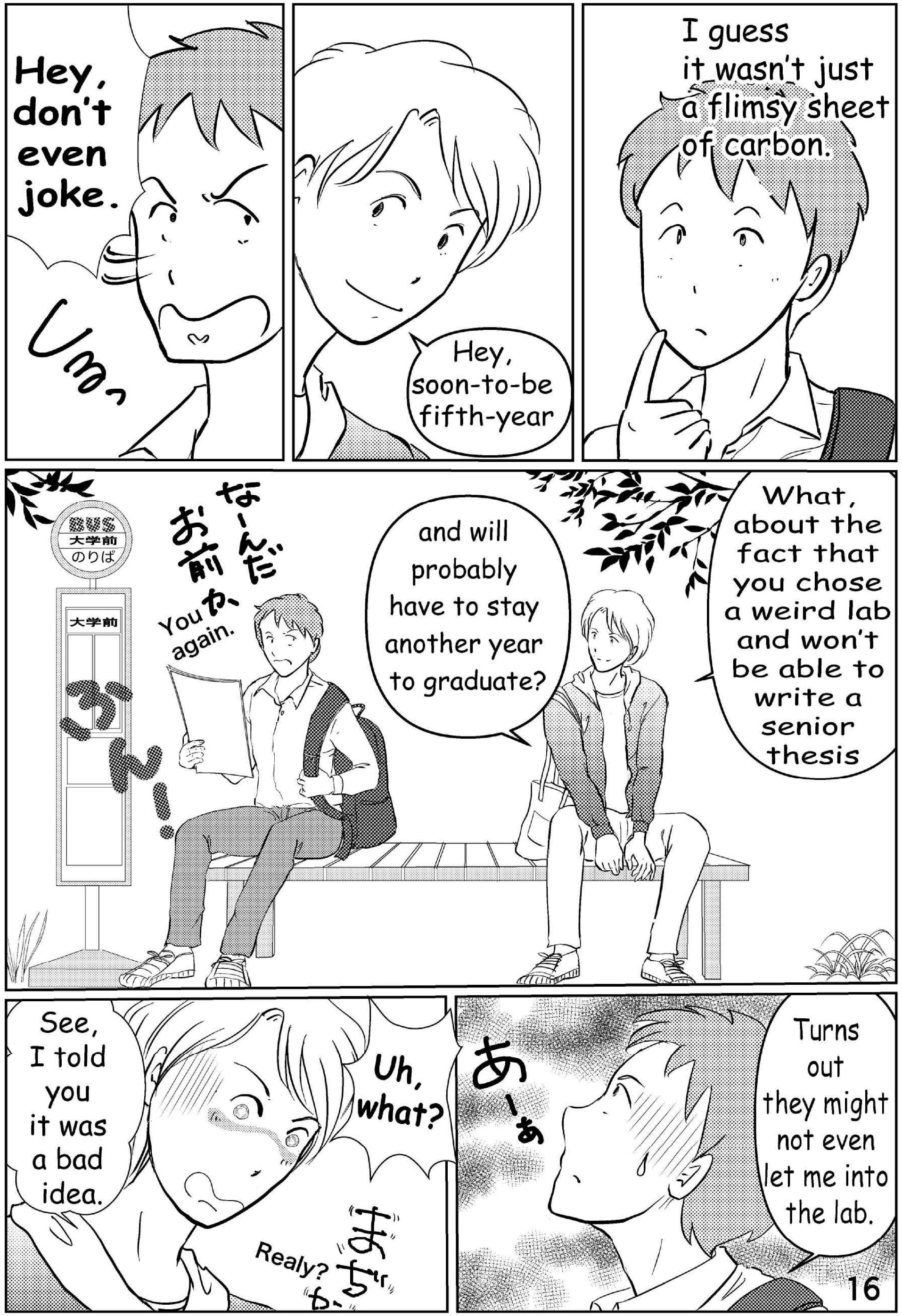

え… エーゴ
in English...
Well, good thing there are apps nowadays to help with the English.
Pencil and sticky tape
But oh god, I'm getting dizzy just looking at all this text...
And here,
Sticky tape?
Scotch tape??

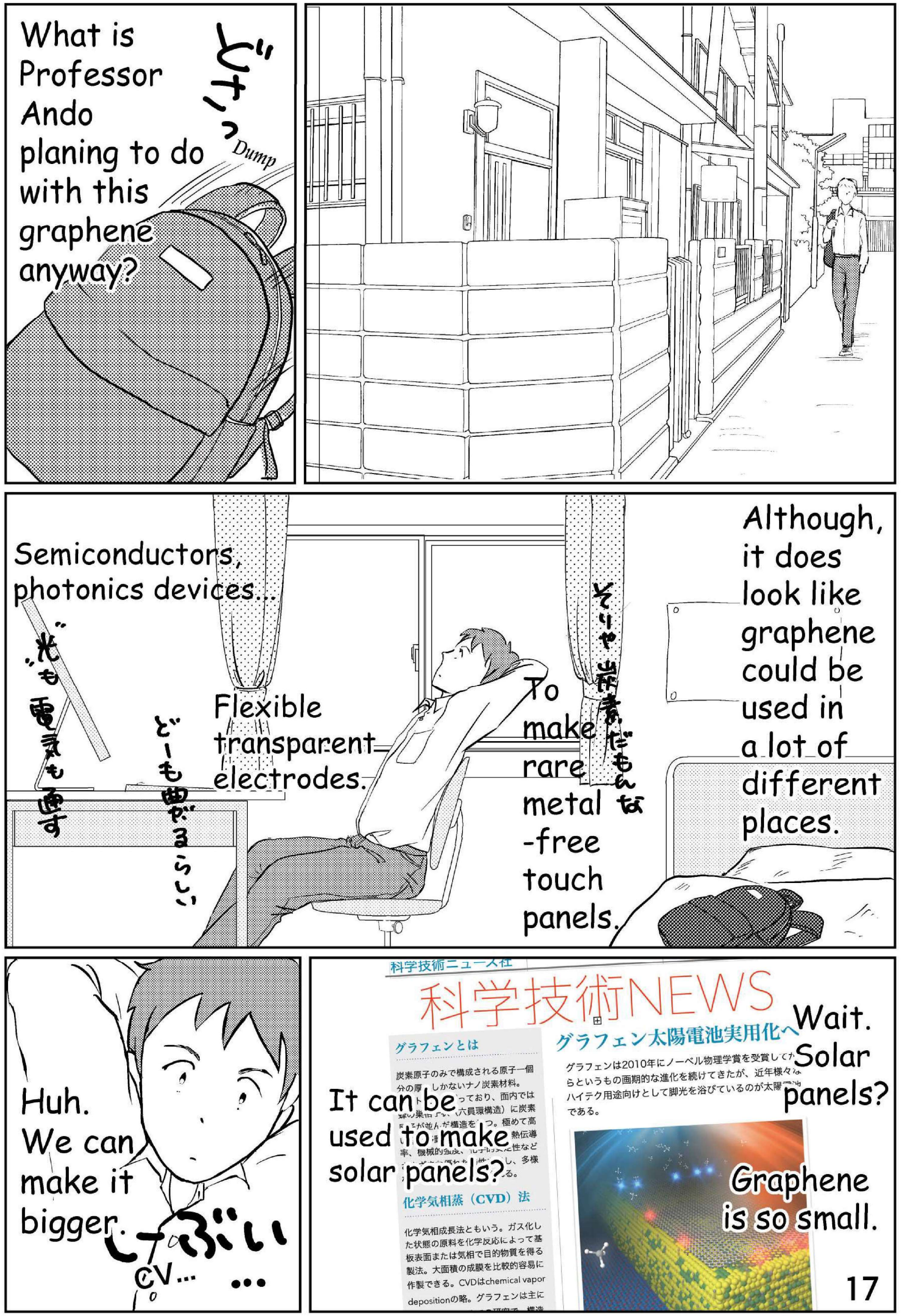

Scotch tape is that white tape, isn't it?
They pealed out with that tape?
They really won the Nobel Prize with that?
???
This is...
cutting-edge science?
Um.
Um, excuse me,
where's the professor?
カチ
カチ
Not here.
Not here?


Busy with a conference.
Aha
He won't be around for a while.
しまったデータが…
Oops
Well.
Alright then.
But I'm not even gonna be able to introduce myself?
But I've never see his face...
Oh well. Back to research.
Squeeze
What should I do this when I'm done reading it?
こんなにたくさん…
and...this is too much for me
Mm, come back after class the day after tomorrow.
You'll do the same experiment they did to make the graphene.

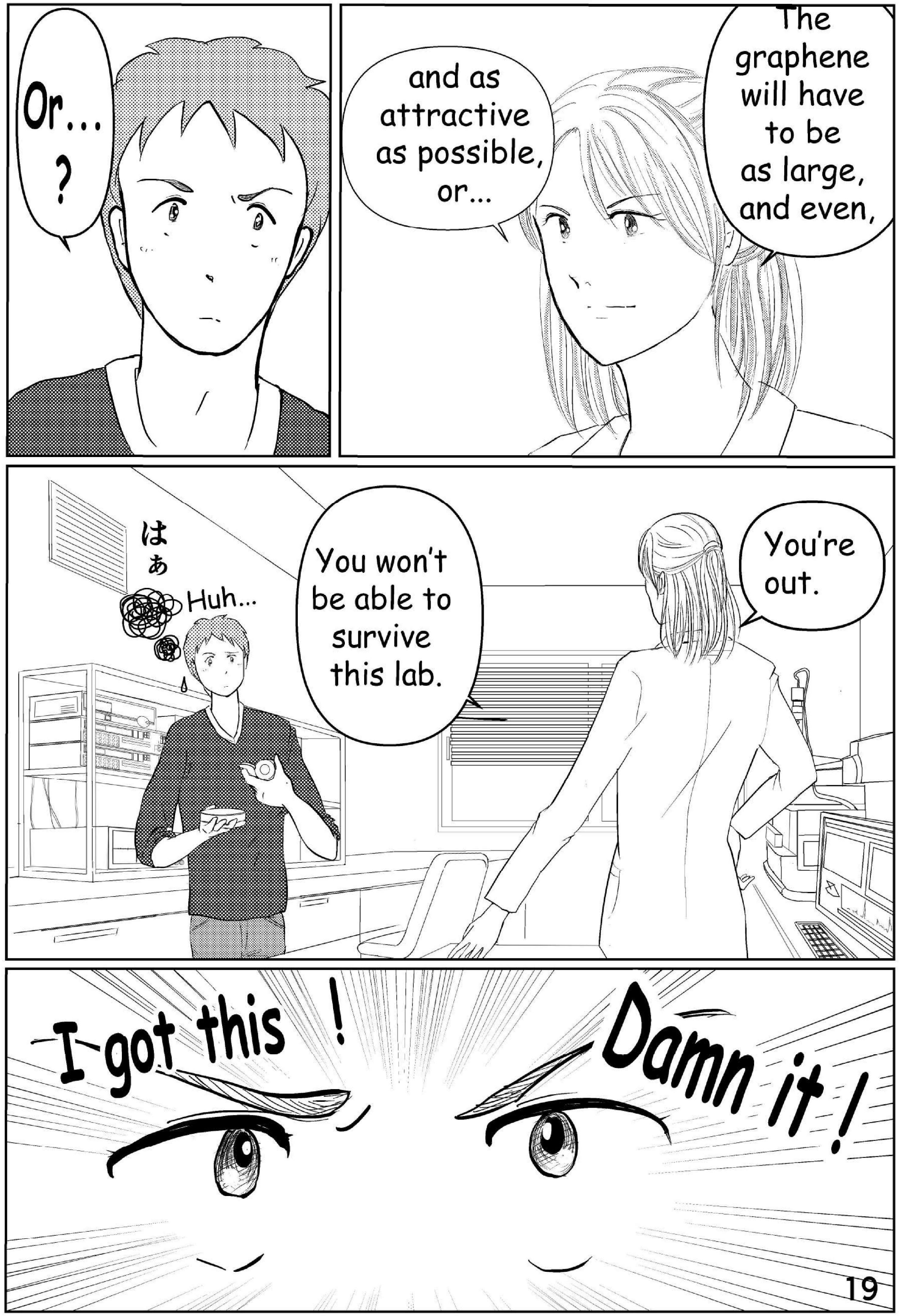

Thank you!
ガチャ
chack
God, I said I'd do it, but... what a situation.
Ando Laboratory
You can't do it, you're out.
パタン
Thud
Am I gonna be a stray senior, wandering around looking for a lab?
Oh well. Time to do some research.
16:34
This is the experiment that won them the Nobel Prize
What's Graphene?
"Super Low-Tech Experiment Wins Scientists Nobel Prize." Makes a great headline, but... How does that actually work?
"Super Low-Tech Experiment Wins Scientists Nobel Prize."
2010 Nobel Prize in Physics
Dr.Konstantin Novoselov
Dr.Andre Geim
These two really became Nobel Prize winners because of some Scotch tape?


And now that I'm actually thinking about it, how do they even make a sheet that's only an atom thick?
ゴン
こわす
Smash
ゴリゴリ
やすりで削る
Grind
パカッ
切る
Snap
I see.
So that itself was the mystery.
※SCIENCE 22 Oct 2004 Vol 306, pp. 666-669
Electric Field Effect in Atomically Thin Carbon Films
K.S. Novoselov, A.K. Geim, S.V. Morozov, D. Jiang, Y. Zhang, S.V. Dubonos, I.V.Grigorieva, A.A. Firsov
Department of Physics, University of Manchester, M13 9PL, Manchester, UK
Institute for Microelectronics Technology, 142432 Chernogolovka, Russia
But what were they even planning to do with something like that?
And... the paper she gave me was the one ※that got them the Nobel Prize.
Huh
I guess it conducts electricity really well?
Electric Field Effect? elections and holes...
でんし と 穴ボコ
正孔
vary the carrier concentration in a semiconductor devices
半導体デバイスの電荷密度を変化させ
Whoa. That's pretty cool.
single layer grapheme…
making devices from them…
単相のグラフェンから デバイスを作り…

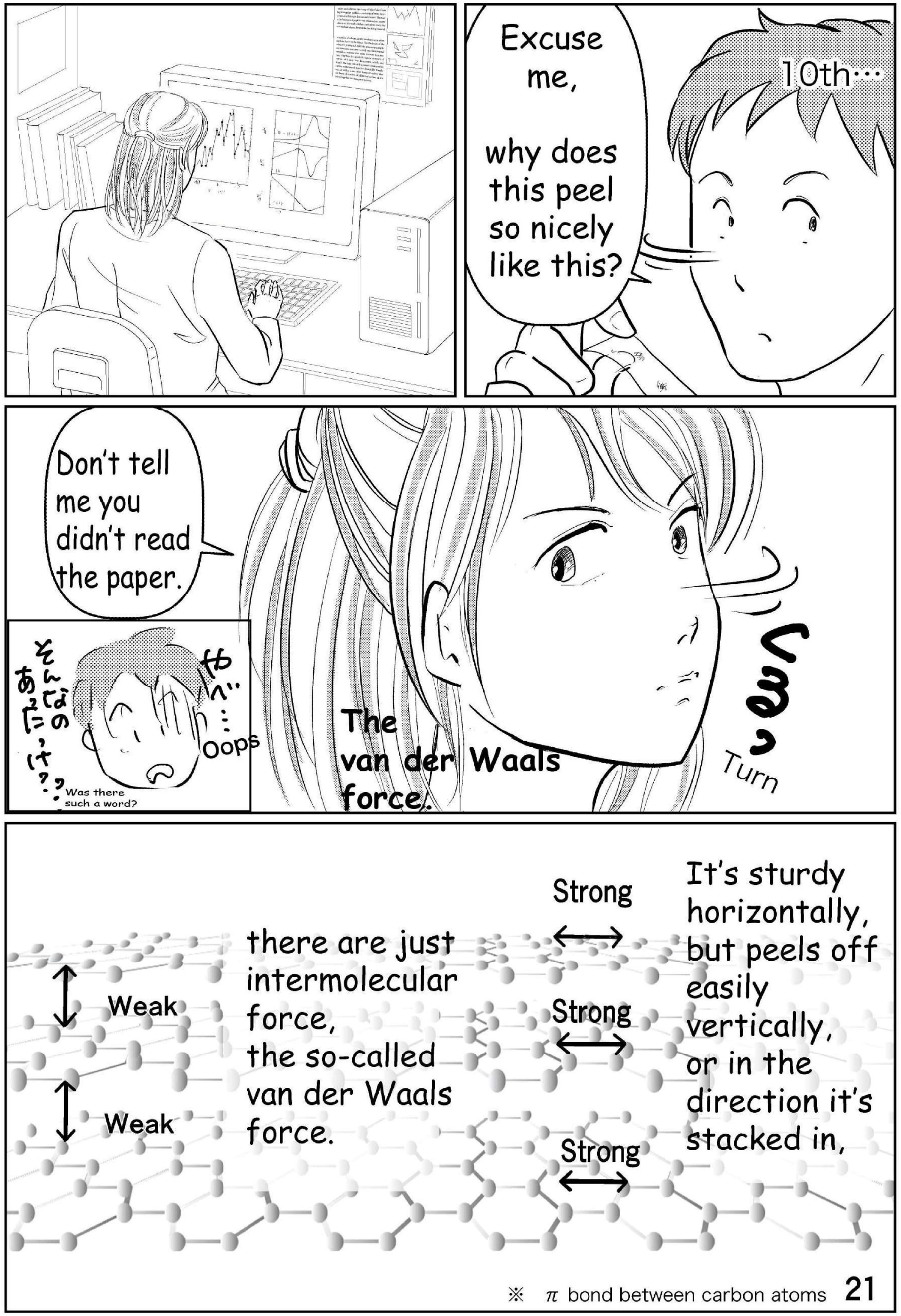

I guess it wasn't just a flimsy sheet of carbon.
Hey, soon-to-be fifth-year
Hey, don't even joke.
しーん
なーんだ お前か。
You again.
What, about the fact that you chose a weird lab and won't be able to write a senior thesis
and will probably have to stay another year to graduate?
ぎくっ!
BUS
大学前
のりば
大学前
あーぁ
Turns out they might not even let me into the lab.
Uh, what?
まぢか
Realy?
See, I told you it was a bad idea.

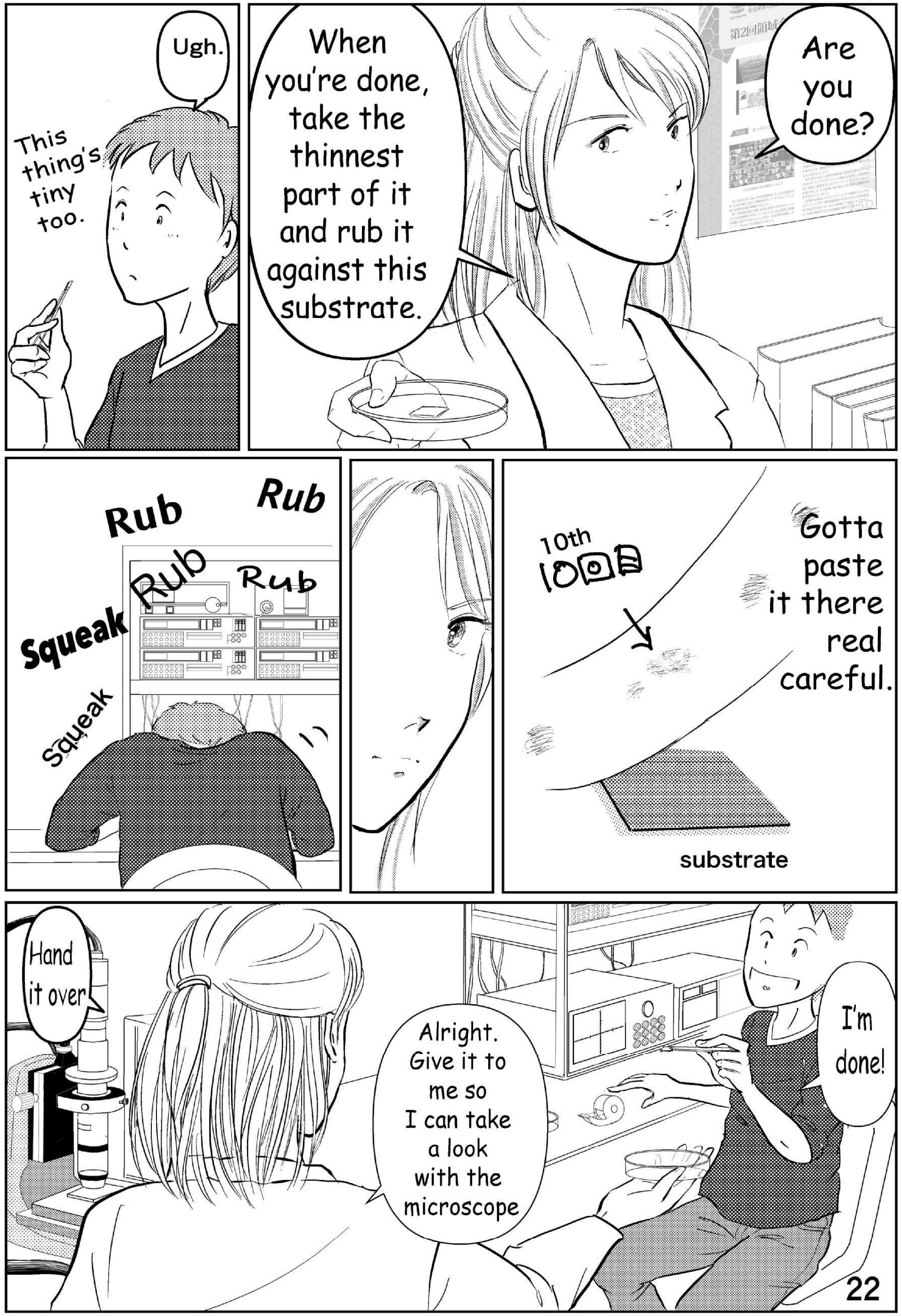

What is Professor Ando planing to do with this graphene anyway?
どさっ
Dump
Although, it does look like graphene could be used in a lot of different places.
そりゃ炭素だもんな
To make rare metal-free touch panels.
Flexible transparent electrodes.
どーも曲がるらしい
Semiconductors, photonics devices...
光も電気も通す
Wait. Solar panels?
Graphene is so small.
It can be used to make solar panels?
科学技術ニュース社
科学技術NEWS
グラフェンとは
グラフェン太陽電池実用化へ
化学気相蒸（CVD）法
Huh. We can make it bigger.
しーぶいい…
CV...

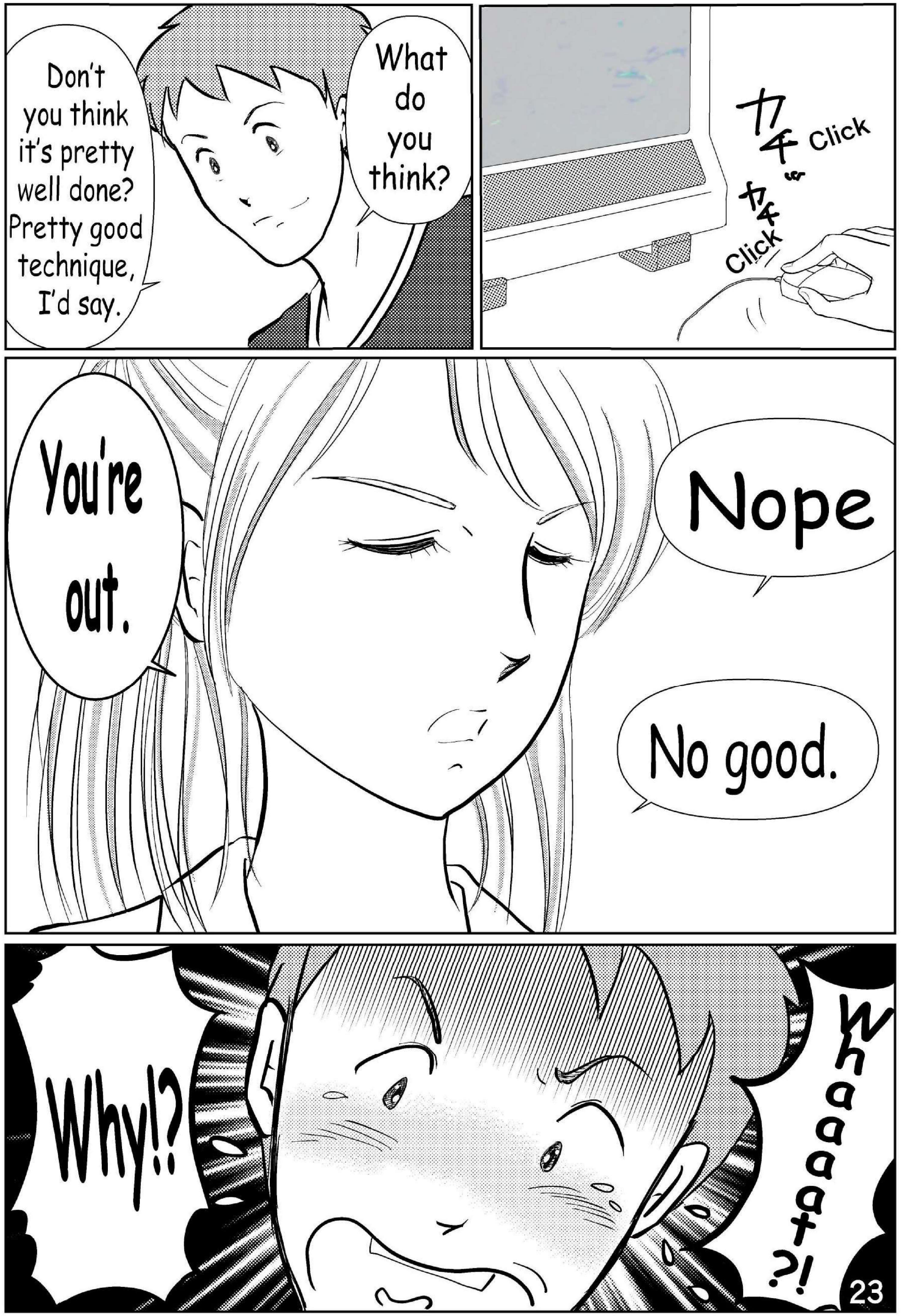

Day of the lab entrance test
Hello
This is graphite.
He actually came back.
You're gonna sandwich this in some Scotch tape, then open it back up, to make it thinner.
Once you do it about 10 times and it gets a lot thinner...
...you'll transfer it to a silicon substrate
and look at it under a micro-scope.
あ
テープ…
Oh, tape

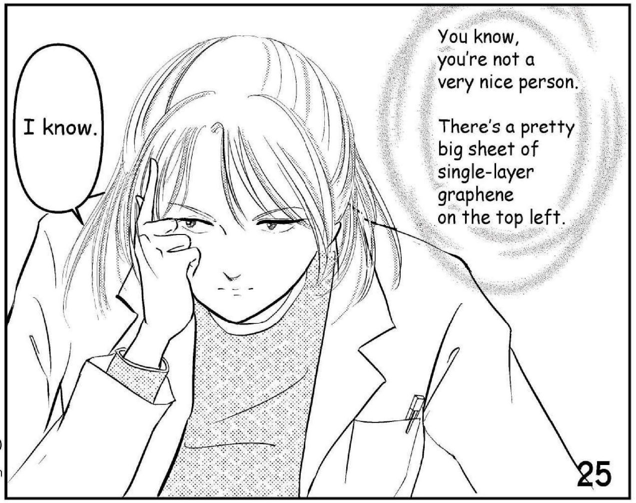

The graphene will have to be as large, and even,
and as attractive as possible, or...
Or... ?
You're out.
You won't be able to survive this lab.
はぁ
Huh...
Damn it !
I got this !


But god, am I clumsy.
とほほ…
Why is it so small
Do not touch it with your bare hands!
あい…
yeees…
お～怖ぃ…
Scared me…
But it's pretty. This is the mass of carbon.
Press it together, and open it back up.
1st
2nd
3rd
Hey, it actually peels away pretty nicely.
Am I… actually pretty good at this?


10th…
Excuse me, why does this peel so nicely like this?
Don't tell me you didn't read the paper.
くるっ
Turn
The van der Waals force.
やべ…
Oops
そんなのあったっけ？
Was there such a word?
It's sturdy horizontally, but peels off easily vertically, or in the direction it's stacked in,
there are just intermolecular force, the so-called van der Waals force.
Strong
Strong
Strong
Weak
Weak
※ π bond between carbon atoms


Are you done?
When you're done, take the thinnest part of it and rub it against this substrate.
Ugh.
This thing's tiny too.
Gotta paste it there real careful.
10th
10回目
substrate
Rub
Rub
Rub
Rub
Squeak
Squeak
I'm done!
Alright. Give it to me so I can take a look with the microscope
Hand it over


カチッ
Click
カチ
Click
What do you think?
Don't you think it's pretty well done? Pretty good technique, I'd say.
Nope
No good.
You're out.
Whaaaaat?!
Why!?



Supervised ; Group A02 Tomoki Machida, Professor, Institute of Industrial Science, The University of Tokyo
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