IN THE COMMONWEALTH COURT OF PENNSYLVANIA

League of Women Voters of Pennsylvania, Carmen Febo San Miguel, James Solomon, John Greiner, John Capowski, Gretchen Brandt, Thomas Rentschler, Mary Elizabeth Lawn, Lisa Isaacs, Don Lancaster, Jordi Comas, Robert Smith, William Marx, Richard Mantell, Priscilla McNulty, Thomas Ulrich, Robert McKinstry, Mark Lichty, Lorraine Petrosky,	)	
Petitioners,	)	
v.	)	No. 261 M.D. 2017
The Commonwealth of Pennsylvania; The Pennsylvania General Assembly; Thomas W. Wolf, In His Capacity As Governor of Pennsylvania; Michael J. Stack III, In His Capacity As Lieutenant Governor of Pennsylvania And President of the Pennsylvania Senate; Michael C. Turzai, In His Capacity As Speaker of the Pennsylvania House of Representatives; Joseph B. Scarnati III, In His Capacity As Pennsylvania Senate President Pro Tempore; Robert Torres, In His Capacity As Acting Secretary of the Commonwealth of Pennsylvania; Jonathan M. Marks, In His Capacity As the Commissioner of the Bureau of Commissions, Elections, and Legislation of the Pennsylvania Department of State,	)	Pages 1106 - 1396
Respondents.	)	

COMMONWEALTH COURT OF PENNSYLVANIA, Volume IV

BEFORE: HONORABLE JUDGE KEVIN BROBSON

DATE: DECEMBER 14, 2017; 9:32 A.M.

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PENNSYLVANIA JUDICIAL CENTER
601 COMMONWEALTH AVENUE
HARRISBURG, PA 17106

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P R O C E E D I N G S

Harrisburg, Pennsylvania
December 14, 2017; 9:32 a.m.

THE CLERK: Good morning, everyone. Welcome to Commonwealth Court.

Just a reminder, make sure all cell phones and electronics are turned off, other than counsel.

Thank you.

(Pause.)

THE CLERK: All rise. The Commonwealth Court is now in session, the Honorable Judge Kevin Brobson presiding.

THE COURT: Good morning. Please be seated, everyone.

Are Legislative Respondents prepared to call their first witness?

MR. LEWIS: We are, Your Honor.

THE COURT: Okay. Please do.

MR. LEWIS: Your Honor, we call Dr. Wendy Cho to the stand.

- - -

WENDY TAM CHO, PH.D.,
after having been first duly sworn, was
examined and testified as follows:

- - -

VOIR DIRE

- - -

BY MR. LEWIS:

Q. Good morning, Dr. Cho. Would you please state your full name for the record?

A. Yeah. It's Wendy Tam Cho.

Q. Okay. Dr. Cho, I'm going to put -- put up on the screen what's been marked Legislative Respondents' Exhibit 10.

Dr. Cho, do you recognize this as your -- with the laptop button on -- do you recognize this as your curriculum vitae?

A. Yes, I do.

Q. Okay. And does this document summarize your academic and professional background and experience?

A. Yes, it does.

Q. Okay. Can you summarize for us your educational background?

A. Sure.

Can you make that bigger?

Q. Sure.

A. Not that you don't know it, but -- I have Bachelor's degrees in political science and math, I have Master's degrees in political science and statistics, and I have a Ph.D. in political science.

Q. Okay. And from what institution or institutions did you get those degrees?

A. All from the University of California at Berkeley.

Q. Do you have any other postgraduate education besides your Master's and your Ph.D.?

A. I went to law school for a year.

Q. And where did you go?

A. Cornell University.

Q. Okay. And where are you currently employed?

A. The University of Illinois at Urbana–Champaign.

Q. Okay. And in what capacity?

A. I'm a full professor, and I have multiple appointments in the Department of Political Science, in the Department of Statistics, in the Department of Asian American Studies and the College

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of Law, and also at the National Center for Supercomputing Applications.

Q. And what's your position with the National Center for Supercomputing Applications?

A. I'm a senior research scientist.

Q. And have you published in the field of redistricting?

A. Yes, I have.

Q. And where have you published on that -- on that subject?

A. I've published on redistricting in multiple fields. I've published in the field of high-performance computing, computer science, operations research, statistics, geography, political science and law.

Q. Okay. And are your publications in these fields and others fairly summarized on Pages 2, 3, 4 and -- 2, 3 and 4 of your CV?

A. Could I see 2, 3 and 4?

Q. Sure.

A. Yeah, that would be it.

Q. Okay. And are these publications all in peer-reviewed journals?

A. Yes.

Q. Are you a member of any professional

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associations in the area of political science?

A. Yeah. I'm a member of the American Political Science Association.

Q. Okay. And what is your role with the American Political Science Association?

A. I'm just a member. In the past, I was a -- I was part of the executive counsel, which is a -- is the governing association for -- is the governing body for the Association. It's -- you -- it's an elected body, and you're elected there by discipline-wide election.

Q. Are you a member of any professional associations in the field of statistics or operational research?

A. I'm a member of some high-performance computing societies.

Q. And I see, Dr. Cho, on your CV a reference to being a John Simon Guggenheim fellow. Can you tell us what that is?

A. Yeah. The -- the Guggenheim fellowships are awarded every year to -- I think they -- they can be awarded to anyone. It's for creativity and promise. So the award is given based on your past work. So it's -- I forgot the phrase, but I think it's -- it's on my CV.

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What does it say? Can you remind me? What is the phrase that they give?

Q. We can have you refer to --

THE COURT: Dr. Cho, there's probably a white binder over there somewhere.

THE WITNESS: Here?

THE COURT: Behind those two black binders, there's a white binder, and that has all of the trial -- or all of the premarked exhibits. So just make sure -- if you're referred to an exhibit by number, just look at that one.

THE WITNESS: Okay.

THE COURT: So I think, right now, you're looking at 10?

THE WITNESS: All right.

So impressive achievement in the past and exceptional promise for future accomplishment.

So it's given mostly to scholars or -- or also to artists. So, for instance, the year I got it, my sister mentioned to me that -- she looked at the list. It's published in the New York Times. They take

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out a full-page ad every year for it -- and she saw her favorite fictional writer. And she wondered what I was doing on the list, too.

BY MR. LEWIS:

Q. And what year were you awarded that fellowship?

A. 2016.

Q. Have you served on any government councils or panels in -- in the field of elections?

A. Yeah. I was a member of -- I'm trying to recall the name of it now, but it was with President Obama -- his Election Commission, I think he called it.

Q. The Commission on Election Administration?

A. Yeah, that was it.

Q. Okay. Have you received any -- any grants in connection with any work that you do in the area of redistricting?

A. Yes, I've received multiple grants recently from the National Science Foundation for a grant to support my computational work on redistricting. I've also received multiple grants of computing allocation time on the Blue Waters

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supercomputer.

Q. And what is the Blue Waters supercomputer?

A. The Blue Waters supercomputer is the fastest super research computer in the world. It's got 72,480 cores, and it runs at approximately 13,000,000 times faster than your average laptop.

Q. My laptop feels like it's been put in its place.

THE COURT: It sounds like a statistician's dream.

BY MR. LEWIS:

Q. Do you teach in the fields of political science?

A. Yes.

Q. Do you teach elections?

A. I teach a class in election law; I teach another class in constitutional law; I teach a class in racial ethnic politics; I've taught classes on data science, big data, all at the undergraduate level.

Q. Okay. And do you teach in the field of statistics?

A. Yes, I teach multiple classes at the graduate level in statistics.

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Q. And do you teach in the field of operations research?

A. I teach algorithms in some of my statistics classes. I wouldn't call them operations research classes.

Q. Okay. And what is your research in the area of redistricting?

A. It's varied. I've published in many different fields. So sometimes, some of my publications are very technical. We publish, for instance, in High Performance Computing, and that is really about high-performance computing algorithms and how you use them. They're not necessarily about redistricting, though I have applied them to redistricting.

I publish in Operations Research, which are about algorithms, not necessarily on high-performance computers but just algorithms for -- again, they're actually just algorithms. But I have applied those also to redistricting.

I've published in law reviews, and those generally don't take a technical bent at all. They just talk about how I would apply my work to redistricting.

I published in the field of political

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science where, again, all these publications take the bent of the -- of the journal that I publish in, so the political science publications are about political implications. The law ones about law. The Operations Research ones are about algorithms. The High-Performance Computing ones are about how you adapt to a massively parallel architecture.

Q. And what -- and what is the research that you conduct concerning redistricting?

A. I've written on multiple different topics. I've also written on the Voting Rights Act. I've written on how you measure racially polarized voting. That stuff gets published in statistics.

I've worked on algorithms for how to explore redistricting maps. It's an array of things. They all have to do with redistricting.

Q. Okay. Tell me a bit about your research as it applies to, you know, exploring redistricting maps.

A. So this has been an interest of mine for actually a very long time. I've -- I had this idea many, many years ago, more than 20 years ago, that you could explore redistricting maps on computers. And I've written algorithms to do that dating back more than 20 years.

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But most of that work, 20 years ago anyway, didn't get very far. I wrote the algorithms and I watched them run, and they ran for a long time. And it wasn't that fun to watch them run, so I killed them after a while; wasn't very happy with them.

But a lot of the work has continued over the decades, and so some of that work that didn't work 20 years ago works better, even though I haven't really added that much to it because the computers are better.

Some of that work I have improved over the years because -- for instance, when the University of Illinois got the Blue Waters supercomputer, it was -- it was a secret goal of mine that I really wanted to use it. And so, you know, my redistricting ideas came back to me, and I thought, there's some way to use that supercomputer to do redistricting.

So I updated my skill set and learned how to work on a supercomputer. And that is one of my current projects, is working on that -- on the supercomputer, writing algorithms, for instance, for redistricting.

But I write algorithms for other things on the supercomputer, too, not just redistricting.

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Q. What is the field of -- of operations research?

A. It's -- it's basically about algorithms, how you -- how you build algorithms, optimization algorithms, for instance, to perform different kinds of tasks.

Q. And how does that task apply to the field of redistricting?

A. So, for instance, if you want to explore the space of possible redistricting maps, you -- you could write an algorithm, all right, to explore that space. And the operations research angle of it would be, you know, how -- how do you write such an algorithm, how do you write such an algorithm to work effectively and efficiently to explore that space.

Q. Okay. And, Dr. Cho, have you ever studied the use of simulations in -- in the redistricting area?

A. Yeah. That's an area of current research of mine.

Q. And how long have you studied that subject?

A. More than 20 years.

Q. Okay.

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MR. LEWIS: Your Honor, at this point, we would move first for the admission of Legislative Respondents' Exhibit 10, Dr. Cho's CV.

THE COURT: Any objection?

MR. GERSCH: No objection.

THE COURT: Without objection, Legislative Respondents' Exhibit 10 is admitted.

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(Whereupon, Legislative Respondents' Exhibit Number 10 was admitted into evidence.)

- - -

MR. LEWIS: Your Honor, at this time, we would also move for the admission of Dr. Cho as an expert witness in the subjects of political science and with a focus on political geography, redistricting and American elections; and additionally, in the fields of operation research, statistics and probability, and high-performance computing.

THE COURT: Dr. Cho has been offered as an expert witness in this case in political science with subcategories: political geography, redistricting and American elections; as well as operations research, statistics and probability and high-performance computing.

Is there any objection?

MR. GERSCH: May we voir dire, Your Honor?

THE COURT: You certainly may.

- - -

VOIR DIRE

- - -

BY MR. GERSCH:

Q. Good morning, Dr. Cho. My name is David Gersch, and I represent the Petitioners in this matter.

You and I have never met in person; is that right?

A. That's correct.

Q. All right. I have a few questions, really, on a small subset of the areas that you were tendered on.

Dr. Cho, have you ever submitted to a peer-reviewed journal a proof concerning reversible Markov chain?

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A. I have not.

Q. Have you ever done a proof concerning reversible Markov chain?

A. I have not.

Q. Is there any article or presentation on your CV where you've done any kind of -- or submitted any kind of formal mathematical proof?

A. A formal mathematical proof?

Q. Yes.

A. And how would you define that?

Q. A proof of -- of -- of a theorem, such as, you know, the Pythagorean theorem, A squared plus B squared equals C squared.

Have you submitted anything like that to a peer-reviewed journal?

A. Certainly not like that, no. I have no Pythagorean theorem to my name.

Q. I'm sorry. I didn't hear the last part.

A. I have no Pythagorean theorem to my name.

Q. And no other theorem; is that right?

A. I wouldn't say that. I -- it really depends on what kind of formality you're talking about. But, certainly, I have proved all sorts of

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things.
Q. I'm not asking if you've proved things; I'm asking if you proved theorems, like Dr. Pegden's theorem in the Proceedings of the National Academy of Sciences.
Have you done anything like that, ever?
A. Sure. So in my operations research work, I prove things all the time about the algorithms that I write, which is very much like what he did. He has an algorithm, he provides a proof, and he says, Here's my algorithm to it. And I have done similar things.
Q. Okay. And -- but with respect to reversible Markov chain --
A. Nothing with respect --
Q. -- excuse me, Dr. Cho. I just need to get my question out, then -- then you'll be permitted to answer. But -- but if we talk at the same time, the reporter will never get it down, and no one will know who said what.
A. Sure.
Q. But just to be clear, proving theorems about reversible Markov chains, that's not your business?
A. I have no proof about a reversible

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Markov chain; that is correct.
Q. How about proving theorems that -- that show you can make claims about a larger universe from a nonrandom sample? Have you ever done anything on that subject?
A. That is a known fact that you cannot do that. It -- it does not need to be a subject of a proof.
Q. Well, Dr. Cho, let's -- let's -- let's back up.
Let's assume that someone has a theorem, and the theorem has been proved on that subject.
A. Okay.
Q. You're not saying you've done some work to suggest that's not true?
A. So there's a difference between doing work and having a theorem.
Q. I'm asking whether you have done any work on a theorem. I'm not talking about mathematical proof of a theorem.
Have you done any work on a theorem, any theorem, that has to do with proving that you can make claims about a larger universe from a nonrandom sample?

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A. I have done considerable work on sampling from large solution spaces. I don't know if you want to characterize that as a theorem or not, but I've certainly published on that topic extensively.
Q. Mine is a different question. I'm talking about proving a theorem. I'm not talking about doing research. I'm not talking about doing sampling. Proving a theorem the same way Dr. Pegden proved his theorem in the Proceedings of the National Academy of Sciences.
A. I think we're splitting hairs here, because when you say mathematical theorem, you want to make reference to something specific, which we're not defining.
When I do work in operations research, I show that certain things cannot happen. That is essentially a theorem in -- in the parlance of how you're describing it.
Q. I didn't describe it, I asked if you had done work of the kind that Dr. Pegden did in the Proceedings of the National Academy of Sciences, proving theorems with respect to making claims about a larger universe from a nonrandom sample.
Have you made a proof? And if so,

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what -- what journal do you say you've done it in?
A. Okay. So, again, this idea that you're -- have you provided a proof -- my work and Dr. Pegden's work are of different flavors. He's publishing with a -- more of a mathematical bent. I publish with more of an operations research bent. And those types of work, even though they speak to the exact same phenomena, take on a different flavor.
And so if you want me to say I don't have -- I haven't published in a mathematical journal on that topic with a proof that I called a proof, and then I wrote proof the way he writes it, then I would say yes; I have not done that.
If you want to say that I have not written on that topic in a rigorous way, then the answer is no. I have published in a rigorous way on the exact same topic.
Q. Your highest degree in statistics is a Master's; is that right?
A. This is right.
Q. One other question. I may have had this wrong.
Did I hear you say that you were a member of the Bauer-Ginsburg Commission?
A. I don't even know what that is.

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Q. The Obama commission you referred to on direct.

A. I don't -- he never -- I've never heard anyone refer to it with that name.

Q. Fair enough.

MR. GERSCH: Your Honor, at this time, we object to Dr. Cho's qualifications to testify with respect to Dr. Pegden's work and, in particular, the work covered by his theorem, which I don't think has anything to do with Dr. Cho's expertise.

Of course, we have no objection to her being qualified as an expert with respect to the general areas that she was tendered on, but with respect to that specific issue, her ability to testify about Dr. Pegden's work, the meaning of the theorem, what it covers and what it does not, she's not qualified. It's not her field.

THE COURT: Well, Mr. Gersch, as you know, right now, we're only doing voir dire to determine her expertise to testify as a witness. I'm not going to prejudge any testimony.

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So your motion is denied, because I haven't heard any questions yet. And she will be qualified as the expert -- as an expert in the fields identified by Legislative Respondents.

So your objection is overruled.

MR. GERSCH: Thank you, Your Honor.

- - -

DIRECT EXAMINATION

- - -

BY MR. LEWIS:

Q. All right. Dr. Cho, you were engaged by the Legislative Respondents in this case, correct?

A. Correct.

Q. Okay. And what were -- what were you asked to do?

A. I was asked to comment on the expert reports of Dr. Chen and Dr. Pegden.

Q. Okay. And you issued a report in this case, correct?

A. Correct. Yes.

Q. What did you review to prepare your report in this case?

A. To prepare the report, I reviewed their reports.

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Q. All right. And, specifically, you reviewed the report of -- or did you review the report of Dr. Jowei Chen?

A. I did.

Q. Are you familiar with Dr. Chen's academic work in the area of redistricting?

A. I am.

Q. Are you aware that Dr. Chen, in this case, used a computer simulation to create a set of maps to compare against Act 131 in an attempt to draw conclusions about its -- its partisanship?

A. Yes. He wrote about that in his report.

Q. Can you explain how a computer simulation can be used for the purpose of -- of -- the purpose that Dr. Chen attempts to use it in this case?

A. Yeah. What he's attempting to do is draw a large, random, independent sample of redistricting maps. And if one were to able to do that, then they could use that to make claims about a certain map in comparison to what was possible.

Q. Okay. Is it important to have an independent and random sample of maps for that type of analysis?

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A. That is one way to do it, yes.

Q. Okay. And what was the way that -- how did Dr. Chen approach the question of -- of -- approach his computer simulation?

A. That was his intention, to create a random set of maps. And from that random set of maps, he wanted to make comparison to the current map.

Q. And for that type of analysis, is it important to have an independent and random sample?

A. That was his intention.

Q. Are you familiar with the types of computer simulation algorithms that Dr. Chen employs in his work in this area?

A. I am. I use them all the time. I also teach, for instance, a graduate course in statistics that uses Monte Carlo simulation or Markov chain/Monte Carlo bootstrapping. I do a lot of computational algorithms in statistics. I work with them all the time.

Q. And what type of computer simulation algorithm does Dr. Chen use in his work?

A. It's -- it's -- it's kind of a type of Monte Carlo simulation. I wouldn't say it is exactly one, but I think that is the type of simulation he

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would like to -- to use.

Q. And where does Dr. Chen -- where -- where has he described how his computer simulation algorithm works?

A. In his 2013 article of the Quarterly Journal of Political Science, he describes an algorithm that he uses. In his -- I think his 2016 article with Cottrell, he doesn't give a lot of details, but there -- there is a short description of the algorithm in -- in a footnote in that paper.

Q. And in your opinion, does that algorithm produce an independent random sample of maps?

A. No --

MR. GERSCH: Objection -- just objection as to the vagueness of the question. I'm not sure what the algorithm is in the question.

THE COURT: You don't know what algorithm Dr. Chen used?

MR. GERSCH: No. I wasn't clear whether she was referring to a Monte Carlo algorithm, whether she's referring to an algorithm in the 2013 paper, the 2016 paper.

THE COURT: Could you rephrase the

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question, Counsel?

MR. LEWIS: Absolutely.

BY MR. LEWIS:

Q. Dr. Cho, what type of algorithm is described in Dr. Chen's 2013 paper?

A. He describes something that is like a Monte Carlo simulation.

Q. Okay. What is a Monte Carlo simulation?

A. It's basically trying -- it's basically taking random draws in an attempt to characterize a distribution.

Q. And so how -- how does Dr. Chen's model attempt to do that, to accomplish that goal?

A. What he does -- or what he describes -- I'm not saying he does it here, necessarily -- but what he says in the 2013 article is that he starts with Census geography -- some type of Census geography, say, voter tabulation districts, for instance -- he starts with those Census geography, and then he picks one at random, and then he starts to build a district.

And the way that he describes building a district, in that article, he says that he tries to build them compactly, and the way he does that is --

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MR. GERSCH: Objection. This is beyond the scope of her report. The substance of her report is she can't figure out how Dr. Chen drew -- generated his samples, and she doesn't know enough about his algorithm.

The report is filled with criticisms about how she can't figure out and doesn't know his code and his code isn't disclosed.

THE COURT: Mr. Gersch, you'll have an opportunity to cross-examine.

I'm going to overrule the objection.

Let's move this along.

THE WITNESS: So I'm describing his algorithm in his 2013 paper, which is more limited than the algorithm he used for -- for his report. But he has a very clear description in the 2013 article about these steps of -- of -- of the algorithm, at least a descriptive -- a description. It's just descriptive, meaning it's -- there's not a lot of detail there.

But there's enough detail that I can understand the basics of what he's doing. And what he's doing is he starts with a

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unit -- he randomly picks a unit, and then he starts to build. And the way he starts to build is he takes the centroid of the units surrounding that district that he has, and he takes the one that is closest and then he adds it to it; and then he takes a centroid of the new district and then the centroids of the neighboring units, and then he adds in that way.

Besides choosing the -- the beginning unit randomly, the rest of the -- the algorithm he describes is completely deterministic.

BY MR. LEWIS:

Q. Okay. And how would you describe the algorithm that he employed in this case?

A. So he doesn't describe the algorithm --

MR. GERSCH: Objection. Again -- fine -- that -- go ahead. Withdrawing.

THE COURT: Thank you.

THE WITNESS: -- he doesn't describe the algorithm that he uses to generate the data in -- or the output in his expert report. He says he uses an algorithm. It's a computer algorithm. It's similar to the

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algorithms that he used in his published work, but he doesn't give the exact details of the algorithm in his -- in his report.

But it has the same flavor of the -- it's Monte Carlo-ish simulation.

BY MR. LEWIS:

Q. So if we could just describe this in more simple terms. You know, picture you had -- you had the -- you had an Etch A Sketch -- we'll go back to the Etch A Sketch.

So how does -- how does Dr. -- based on your understanding of -- of Dr. Chen's algorithm or approach that was used in this case -- that was used in his report in this case, how does his -- how does his algorithm draw a map?

A. So his algorithm --

MR. GERSCH: I'm just going to object. There's a lack of foundation. She says she doesn't really know what his algorithm is in this case. He made his code available. If she had wanted to learn how the algorithm was written, that would be fine. The idea of her testifying about how the algorithm works when she hasn't looked at the code makes no sense at all,

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Your Honor.

Objection: lack of foundation.

THE COURT: Overruled. You'll have a chance to cross-examination -- -examine. Your objection goes to weight.

THE WITNESS: So going back to the Etch A Sketch, what he does is he picks a -- a spot at random. So let's say you have an Etch A Sketch, and then you pick a spot at random at the Etch A Sketch. This is where he's going to begin drawing his map.

And so what he does is he says, I'm going to pick a spot at random so I know where it is somewhere on the Etch A Sketch. And then he starts to build around that.

And when I said -- said before that it's deterministic, what I meant by that is the random portion of the algorithm isn't picking where to start. After he picks where to start, the -- how the map is drawn from there is completely determined by -- by his algorithm.

So, for instance, if he were to randomly pick that same spot again, it would build the exact same map; it wouldn't build

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a different map. There's no randomness in the building of the map after the picking of the initial spots for the drawing.

BY MR. LEWIS:

Q. Okay. And did you have to review Dr. Chen's source code in order to reach that conclusion?

A. I did not.

The difference between what he does in his article and what he does for this case is, in this case, there are -- there are more criteria. There are more things that govern how he decides how the map will be drawn. But there are not more random things in how he decides. There are just more things.

So, for instance, in the article, he didn't try to preserve cities, and in his simulation for this case, he did try to preserve cities. And there were other criteria, like incumbency protection, for instance, he didn't use in the article, which he uses for his report here. But those are further deterministic pieces of his algorithm that adds on. He doesn't add on another random element, as far as I can tell.

Q. Okay. And, in your opinion, is this

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deterministic algorithm suitable to draw an independent random sample of maps?

A. It is not. Because they aren't, then, random maps. You start at a random place, that doesn't create a random map. If you start at that same place another time, it creates the exact same map. It doesn't randomly create a different map.

So certain maps will never be drawn, for instance. So if you were to take, like, his algorithm, you pick a random spot, his algorithm would always say to add, let's say, the -- the block to the right. It would never say to pick the block to the left, for instance, so that -- there's no randomness there. The randomness is just in where to start. So if we start there again, it always picks the one to the right, and then the one it picks after that is also determined -- it's -- it's deterministic.

That's what I mean by "deterministic."

Q. Okay. Just to get this housekeeping item out of the way. I'm going to show you what's been marked as Legislative Respondents' Exhibit 11.

Dr. Cho, is this the first page of the expert report that you offered -- that you writ -- wrote in this case?

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A. Yes, it is.
Q. Okay.
Okay. And this report captures the analysis and conclusions that you drew from your work with Dr. -- with -- your review of Dr. Chen and Dr. Pegden's report, correct?
A. Yes, it does.
Q. Okay.
MR. LEWIS: Your Honor, at this point, we would just move for the admission of the expert report.
THE COURT: Any objection?
MS. HANGLEY: No, Your Honor.
MR. GERSCH: Your Honor, I don't have a hearsay objection because the way the Court has ruled before.
I guess I object to it at this time. I don't know what she's going to testify to. There's a lot in the report. If she testifies to the stuff in the report and we cross-examine it, I'll have no objection. If she doesn't address the things that are in the report --
THE COURT: Okay.
MR. GERSCH: -- that's a problem.

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MR. LEWIS: Your Honor, why don't I just move for the admission of the report at the end, if that would make things simpler?
THE COURT: I think that's how the Petitioners did it, so that might be a better way to approach.
MR. LEWIS: Fair enough.
THE COURT: Does that address your concern?
MR. GERSCH: Absolutely.
THE COURT: Thank you.
MR. LEWIS: Fair enough.
BY MR. LEWIS:
Q. Now, Dr. Cho, in your report, did you create an example to -- to illustrate your concern with that deterministic method?
A. Yes, I did.
Q. So if we turn to Page 19 of your report -- 19 and 20.
Can you describe the example -- the -- the example that -- that you created to illustrate your concerns with the algorithm used in this case?
A. Sure.
So these are data that I took from

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another scholar, who created this dataset to examine his MCMC algorithm, so that the idea here is -- and this is something we do all the time in Operations Research when we create an algorithm, is that we want to know if it works, right?
We don't just create an algorithm and just run it. We want to establish the properties of the algorithm. So that is -- so a tactic that we use all the time is you create a very small problem and you run your algorithm on the small problem, and if it successfully recovers the answer in the small problem, then you can feel confident in creating a bigger problem.
And we often ratchet this up. You start with a really small problem. Then you create a little bit of a bigger problem to see if the algorithm still works. And then you create a bigger problem. And this is part of the validation process that -- that scholars will use to validate an algorithm.
So this dataset is what I would consider a very, very small redistricting problem. It has only 25 precincts from the state of Florida. So it's not like examining Pennsylvania, for instance, which has more than 9,000 VTDs and, you

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know, more than 400,000 census blocks. This is 25 precincts from the state of Florida.
I didn't create these data. It was created by someone else. The reason I used it is because they not only created this -- this small dataset, they enumerated all the possibilities for the small dataset. So for -- so, in other words, we know the answer, because we know all the possibilities in this very small dataset.
So I -- I went and got this -- this dataset, and then I wanted to see if the method that -- that Dr. Chen uses would be able to recover basically the -- the right answer in this very small dataset, so I ran an algorithm which is based on my understanding of how he writes his algorithms. And I took out the complexities of his algorithm, like, say, for the state of Pennsylvania, where there are lots of considerations -- incumbency protection, you know, compactness, all this other stuff -- and I ran only an algorithm that would search for three contiguous districts. So there's only one constraint, which is contiguity, no population equality; no compactness; no nothing, just find me three contiguous districts.
And so I ran Dr. Chen's -- the idea of

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his algorithm, which is we picked a unit at random, and then we build districts. And I was trying to see, does it work on this very simple dataset? And I took -- so this dataset has 117,688 possible partitions, or maps, and I let his algorithm run a thousand times, so it created a thousand -- what we -- what he calls "random maps."

They are, in fact, not random maps. There is a random element --

MR. GERSCH: Objection, Your Honor: lack of foundation. This is not Professor Chen's work. There's no description of why this is like Professor Chen's work or why it's an apt comparison. It's irrelevant. It's prejudicial. In addition, it's a narrative answer.

THE COURT: Well, how is it prejudicial, if I'm the finder of fact?

MR. GERSCH: It's prejudicial because it is -- I don't think --

THE COURT: There's no jury here, sir.

MR. GERSCH: I understand that, but I think having evidence in the record which

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is without foundation and misleading is -- is prejudicial to any finder of fact.

THE COURT: You'll have a chance to cross-examine.

MR. GERSCH: Understood, Your Honor.

THE COURT: It goes to weight. Objection overruled.

THE WITNESS: So the point here is that, you know, I've stripped out all the things that I don't know about Professor Chen's algorithm. What I do know is he's claiming there's a random element. He picks a unit at random. I also picked a unit at random.

The districts have to be contiguous, so I'm not imposing some compactness thing; I'm not imposing preserving cities; I'm not imposing population. I'm only asking his algorithm to find a random set of maps that have three contiguous districts.

It's a very simple, what we call "toy" problem. And so I ran it. I asked it to create -- or I created a thousand maps, a thousand maps drawn in this random way. And then if it were to be able to successfully

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sample from the universe of possible maps, which is 117,000 of them -- and they're characterized here by the gray -- I don't know, what would you guys call it -- "blob" -- the gray thing? -- if it were to successfully do that, the red line, which -- which shows his thousand maps, or my thousand maps drawn his way -- the red line would be exactly on top of the gray blob. And it is not -- it systematically oversamples maps -- some maps and undersamples other maps.

So it doesn't -- it doesn't -- every map that is possible is not -- does not have the same chance of being drawn by his algorithm.

BY MR. LEWIS:

Q. Okay. And Dr. Chen -- Dr. Cho -- excuse me -- can you just explain a little bit more --

A. Why that is?

Q. -- why -- why you're confident that you have captured the method that Dr. Chen used to -- or the algorithm that -- or that -- excuse me.

I'll -- let me rephrase that question.

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Why are you confident that the model that you ran in your toy example is consistent with the approach taken by Dr. Chen in this case?

A. It's because all the things that I'm uncertain about in his algorithm don't come into play in this simple example. Those complexities don't come into play because this is such a simple example, it's such a small example, and I ask for only one constraint, which is contiguity. There's not a lot of play there with contiguity. It has to be contiguous. I asked for three contiguous units.

There's not a lot to confuse here. There's -- there's really nothing to confuse. He draws randomly. I draw randomly. It's -- it's the same process. It's -- it's -- this is -- this is a known technique that he's trying to employ and that -- and that I employ.

Q. And just to -- help me -- help me understand, help everyone sort of understand, what is this chart -- this is -- and just for the record, this is Figure 2 --

MR. LEWIS: And, Your Honor, this is a point of order: We also -- since we weren't aware whether or not reports are going to be admitted, we also have an

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Exhibit 12, which I've just put up on the screen, that contains a copy of the figures and tables --

THE COURT: Well, did --

MR. LEWIS: -- from her report.

THE COURT: -- so you have one Exhibit 12 that includes all of her figures and tables. You don't have them separated like Petitioners did.

MR. LEWIS: Correct. That was the way we had -- because these were premarked and that was the way we had them set up.

THE COURT: Okay. You have multiple -- you have a world of options here, then. You could separate them out and make them separate exhibits; you could move the table -- move the single exhibit at the end at the same time that you move the report; or you could just move the report.

I'm sure statisticians can come up with any number of additional options beyond that. Those are the three that my mind can process right now.

MR. LEWIS: Okay. I think I'll vote to move everything at the end.

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THE COURT: Okay.

MR. LEWIS: I think that'll be the easiest way to handle the housekeeping matter.

THE COURT: That doesn't preclude you from using blow-ups, which the Court really appreciates, and I'm sure the parties do as well.

MR. LEWIS: Absolutely, Your Honor.

BY MR. LEWIS:

Q. Okay. So, Dr. Cho, we'll use this version since it's a little bit -- a little bit larger.

THE COURT: And just for marking purposes, what you're showing right now has been premarked as Exhibit 12?

MR. LEWIS: Legislative Respondents' 12, yes, Your Honor.

THE COURT: Okay. Okay.

MR. LEWIS: Yes, Your Honor.

BY MR. LEWIS:

Q. Okay. So, Dr. Cho, we'll start this real simple.

What -- what are the axes on this figure?

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A. So on the -- on the bottom is -- I labeled it Partisan Metric. It is -- it is a metric that was in the dataset. It's not one that I created, this dataset that -- I got from somebody else. It was -- it is a Republican dissimilarity index, which was built, again, not by me but by the people who wrote the -- who built the dataset. And that comes -- it's -- the dissimilarity index comes from a 1988 article in Social Forces by Massey and Denton, where they created this dissimilarity index to study segregation, and it basically measures the isolation of -- of a particular group.

So they computed the Republican dissimilarity index for the 25 precincts that they had in the dataset, and I'm just using that. But the -- the metric on the bottom doesn't matter. If you're able to recover a random sample of the maps, you should be able to recover any metric, partisan, nonpartisan, whatever. Any -- anything you wanted to recover about the distribution, you would be able to do if you had a random set of maps.

Q. Okay. And the vertical axis of this figure, Frequency, what does that mean?

A. That's just showing how often a certain map showed up with that partisan metric.

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Q. Okay. And you described the gray blob. What is it?

A. So the gray blob shows you, for all possible maps that can be drawn that are valid for this dataset, so three contiguous districts -- this is the partisan metric of those maps, all possible maps --

Q. Okay. Okay.

A. -- and the red line shows you the distribution of -- that -- that an algorithm like Chen's recovered.

MR. GERSCH: I'm going to interpose another objection: The algorithm that she used to build this thing was not disclosed in the backup for this case. This is the first time we've heard that she built this.

THE COURT: Response?

THE WITNESS: From me?

MR. LEWIS: No, it's for me.

We made the -- the dataset that was used to produce this -- that Dr. Cho used to produce this analysis is publicly available, and the link to it was actually, you know, included within the scope of the report.

There was not a request made of us

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to disclose any -- any code, necessarily. And -- There wasn't.

THE COURT: Hey -- so we --

MR. LEWIS: We --

THE COURT: Hold on a second.

Counsel, suspend.

We've had some light moments in here. I don't think that was an appropriate one, okay?

So let's -- let's allow counsel to finish his response to the objection.

MR. LEWIS: So we did have -- you know, we had -- we agreed to exchange data. We, in fact, for example, in the cases of -- of Dr. -- of Dr. Chen, you know, we had to ask for the code. They didn't ask for any code that we generated, that I'm aware of.

MR. GERSCH: Your Honor, this is just not true. What happened is that the Respondents proposed that in the case of the experts, we exchange the underlying data. We negotiated that over three days, and the Petitioners agreed to their proposal.

After our experts filed their reports, they said, No, no, the underlying

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data is not enough; we must have this; we must have that; we must have the code. At that point, we agreed with them: We would produce those things that they asked for, including the code, provided they produced, when they produced their report, exactly the same thing.

We are learning for the first time that she used an algorithm to build this thing, and the code has never been produced, notwithstanding the representation that they would produce the code if we would produce the code.

MR. LEWIS: Your Honor, I mean, if we need to go back and pull the e-mails and see exactly what the agreement was or was not, we can do that.

I think as a -- you know, as a general concept, this was a very simple proof of concept. She has fully explained what it is, and it's not our burden of proof on the elements. We are not offering an opinion on the validity or -- through Dr. Cho of the validity of Pennsylvania's map.

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She's using an example to illustrate a principle -- a principle. That's what she's doing.

THE COURT: Dr. Cho, as I understand your testimony on what algorithm you used to run this example, you've indicated that, to the best of your knowledge, you used an algorithm written by Dr. Chen, except you're taking out certain variables. Am I correct?

THE WITNESS: Yeah, I wouldn't say it's an algorithm taken by Dr. Chen. He uses a general class of algorithms, and I am also using that exact same general class of algorithms.

THE COURT: And are those algorithms disclosed in your expert report?

THE WITNESS: Yeah, I describe what I'm doing.

THE COURT: Okay.

MR. GERSCH: You know, if I may, this is the e-mail from Legislative Respondents' counsel, Shawn Sheehy, on November 29th, 2017, after we had gone through this

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negotiation/renegotiation of what Legislative Respondents' counsel wanted.

It's addressed to Mr. Jacobson: Daniel, I can confirm that we will provide code/information/data on December 4. She has now said for the first time that she has written an algorithm -- that's a code -- and it has not been produced.

THE COURT: Well, I don't know -- first of all, I don't know that an algorithm is a code. I don't know -- for me, code -- I thought code was something that you plug into a computer that prompts -- you're actually writing a computer program. That's my understanding of code. But, again, I'm just a lawyer. What do I know?

MR. GERSCH: Your Honor, if I may, you're exactly right. That is what the code does. That's what runs the algorithm. The code tells the computer, Here are the things we want you to do. It carries out the algorithm. It makes the computer run the algorithm. You're exactly right, Your Honor.

They said they would produce it.

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It's the first time we heard that she's written code. It hasn't been produced.

THE COURT: I haven't heard that she's written code.

MR. GERSCH: She testified that she's written code.

THE COURT: I haven't heard the word "code." I haven't heard the word that she wrote "code."

Again, remember, the reason why we have expert testimony is because there's something that a human being, like me, doesn't understand as a factfinder.

So I haven't heard a question about writing code. I heard that she used a standard algorithm and did a test of Dr. Chen's results compared to that algorithm. I haven't heard anything about writing code.

Now, if you're correct and she, in fact, did write code and run an algorithm and the code was not produced to you, then you might have a valid objection.

MR. GERSCH: May I voir dire on that point?

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MR. LEWIS: We're looking for something, Your Honor.

THE COURT: What are we looking for?

MR. LEWIS: Well, the --

THE COURT: Counsel, this is very simple. They had an expert testimony -- expert who testified to statistics and writing an algorithm and a code and running it on a computer, and your folks, reasonably and understandably, asked them to disclose everything: the dataset, the code, the algorithm and everything. And you got that.

In return, you have an expert that is being -- completely understandable -- put up to be critical of their expert. I completely understand that. But in the process of being critical of that expert, the allegation is that your expert, herself, wrote code, ran an algorithm, used the dataset, but that you did not disclose the very things that you demanded that their expert disclose.

That's the -- it's -- it's a fairly straightforward objection.

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MR. LEWIS: Your Honor, in response to that, Number 1, I will accept counsel's representation concerning Mr. Sheehy's e-mail, if that's -- you know, I have no reason to dispute that.

Look, I mean, we can ask -- look, is the answer was there code that -- you know, we can find out if there was code; I can ask the question. We turned over the data that was relied on --

THE COURT: I don't think there's an objection based on the dataset.

MR. LEWIS: Right. Understood. Understood.

-- with respect to any -- to any code, any specific machine code, we did not turn over machine code.

Now, what I would say on that point as well is when Petitioners filed their Frye motion regarding Dr. Cho, we specifically represented, you know, in response that Dr. Cho -- this is on Page 3 of our response to their Frye motion -- we said, Dr. Cho ran a Monte Carlo simulation using the dataset.

We repeated that statement -- I'm

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looking to see exactly where we say it.

MR. FREEDMAN: Counsel, can you identify where in the document you're reading from?

We have a copy here so we can follow.

MR. LEWIS: Absolutely.

I'm on Page 3 in the middle of the -- in the middle of Page 3, and we repeat that -- that statement on Page 7.

So the idea that this was the first that they understood that she had performed, you know, a simulation on her own, you know, that this was discovered for the first time this morning, is not accurate.

Now, look, this is one of the things that can sometimes happen when, you know, we're all under the gun. We had two trials in a row. She had one week to pull this thing together. I'm not sure, to the extent there was code, if it -- you know, if -- if it should have been disclosed, we -- you know, we apologize.

That having been said, I don't see any -- you know, any material harm or

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prejudice to counsel, as she's fully disclosed the algorithm, she's disclosed what she did.

And, you know, it goes to weight, and they can cross-examine her on this subject.

MR. GERSCH: Your Honor, first of all, there's no place in this piece of paper, none, where she says that she ran -- she wrote her own code, ran her own algorithm, as opposed to Fifield's. It's just not said in here anywhere.

Second of all, of course we're entitled to have it, and, of course, they understood that they were entitled to have it.

She's up here testifying -- Your Honor, do you want me to wait for you to read their filing?

THE COURT: No, you can continue.

MR. GERSCH: Okay.

The whole point of her testimony is she's saying, Well, I can look at his algorithm -- we don't agree that she can -- but she says, I can look at his algorithm

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and I can look at the way he ran it, and now I can make a criticism of it.

We were entitled to do that, the same thing, with respect to her algorithm as she claims she is doing to Dr. Chen's. And that's why the code should have been exchanged. And -- and there's -- they have admitted they haven't done it, there was code, it wasn't exchanged. And this piece of paper doesn't -- even if this piece of paper said there was code, they still needed to exchange it -- I'm sorry -- code written by her.

THE COURT: Mr. Gersch, I'm going to allow you to voir dire the witness on this subject.

MR. LEWIS: Your Honor, maybe we can make this simpler. Maybe the way to handle this is, we can -- we can withdraw this -- this figure and we can just ask the witness generally without reference to any code that she's written. Because I just don't think we need -- look, if there's an issue here, you know, we can -- there's no need to, you know, belabor this point.

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MR. GERSCH: The problem is not limited to the illustrations. The problem is her testimony; she's testifying based on work she has done, and she has not turned over the code.

THE COURT: I'm not sure what you're offering at this point in time.

What is your offer?

Are you offering to strike the testimony that she's given with regard to this exhibit and the simulation that she ran here and then moving on to a different line of inquiry?

Is that what you're proposing?

MR. LEWIS: At least with respect to the simulation that she ran, yes. I can -- I can -- I can ask her generally without reference to this --

THE COURT: Okay --

MR. LEWIS: -- her opinions.

THE COURT: -- based on that offer, we are going to strike from the record all testimony by Dr. Cho regarding this exhibit from her expert report and the simulation that she did to compare Dr. Chen's algorithm

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to this dataset.

Mr. Gersch, does that address your objection, at least for the time being, on the testimony that has been given so far?

MR. GERSCH: Yes, it does. Thank you, Your Honor. And thanks to Counsel for that accommodation.

THE COURT: Thank you.

Okay.

MR. LEWIS: We'll take that down.

BY MR. LEWIS:

Q. Dr. Cho, in general, why are -- why are deterministic algorithms not able to draw random samples?

A. That answer is self- -- that question is self-answering. If something is deterministic, it's not -- it's not random, right? If something is random, it's random.

If you put in deterministic pieces, like, this has to happen if that happens; this has to happen if that happens, then it's not -- it's not random. It doesn't matter that you started at a random place, where you move from there is -- is no longer random, and so the whole process itself is not random, despite there being perhaps a random element

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in the algorithm.

Q. Okay. And how does that concern with respect to the -- the randomness of the sample that's drawn -- how does that impact the results of a statistical analysis performed on the basis of a -- of a sample drawn from a deterministic algorithm?

A. So in the case of redistricting, if you're drawing maps that aren't random, then they wouldn't recover the statistic of interest for you, for instance, partisan bias, if you wanted to know the partisan bias of a certain map and you drew other maps from a nonrandom process, then the -- the maps that you draw from that nonrandom process are biased. They wouldn't -- they wouldn't give you the right estimate of the -- of the partisan metric that you're interested in.

Q. And does a -- a deterministic algorithm in the redistricting space -- does that algorithm become more or less random as additional constraints are added?

A. The more constraints you add in -- in a deterministic way, it's -- it's not more or less random; it's just not random. It isn't really a degree; it's a binary.

Q. Okay. And how would one draw a random

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sample of possible redistricting maps?

A. For instance, the technique, Markov chain/Monte Carlo, MCMC, the theory behind MCMC is that you are able to draw a -- a large random sample from an unknown distribution. We have mathematical theorems about that; that is theoretically possible. And so one of the things that people have been trying lately is to develop MCMC algorithms.

No one, that I know of, other than Dr. Chen, is trying to develop something that is -- would do what an MCMC would do. They have the same goal, which is to draw this random set of -- of -- of maps. MCMC actually can accomplish that goal, theoretically, but the problem with MCMC, the thing that people are working on, is that in order to accomplish that goal, you basically need an infinite amount of computing time. It surpasses the ability -- our current capacity to compute to realize the theory of MCMC. So while it's theoretically possible to draw that -- that set via MCMC, it is not practically obtainable in our computing environment.

So that -- that is one way in which you could -- you could approach that. That has its obvious limitations.

The method that Dr. Chen uses simply

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does not have the properties of MCMC. It's not theoretically -- it has no theoretical basis like MCMC does.

Q. And -- and, Dr. Cho, in the fields of political science and statistical research, if someone is to put forward an algorithm and they make a -- claims based on that algorithm, is it generally accepted that that algorithm should be validated in some way?

A. I think in all academic work, algorithms should be validated.

Q. Okay. And how are those algorithms validated in an academic setting?

A. In academic setting, for instance, in Operations Research, people will do something like, for instance, run the algorithm on smaller problems and say, Here, I know the answer to this problem; I'm going to run my algorithm on it; see, look, it recovers the correct answer, or they will benchmark those algorithms on -- on known datasets, or they will -- they will, for instance, use the algorithm and say, Can it -- Can my algorithm identify a better solution than your algorithm?

And even -- even though, then, in a dataset where we don't know the answer, at least you

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can understand the properties of the algorithm, how fast is it able to find good solutions, how effective is it, how efficient is it. There's a whole benchmarking process. It's very -- it's a very standard process.

Q. Okay. And in your own research in the area of redistrictings -- redistricting simulations, have you attempted to validate any -- any of your work?

A. Yes.

So in my publications in Operations Research, that's -- that's exactly what we do. We present an algorithm. We run it on datasets that are known. We run it against other algorithms that are trying to do the same thing. We -- we benchmark them. We show what the algorithms can do. We also produce in those publications the pseudocode for the algorithm. We describe all the steps to the algorithm so that other people can see what we have done and how we have improved upon the current state of -- state of art.

Q. Okay. And, to your knowledge, has Dr. Chen's methodology been validated in -- in an -- you know, through an academic process?

A. In my opinion, it has not --

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MR. GERSCH: Objection: lack of foundation.
THE COURT: Overruled.
THE WITNESS: -- he has published four times, that I'm aware of, with redistricting and where he runs an algorithm. All four of those publications have appeared in political science outlets which -- for which I would not consider it a validation of the algorithm.
The algorithm was not even, in any of those publications, a -- particularly featured in -- in the paper. What was featured was the results.
So, for instance, in Chen and Cottrell, he uses an algorithm; it's described in a footnote. I wouldn't consider that a feature of the -- the publication. Nor would I consider that a validation of the algorithm.
He describes it a little better in the 2013 paper, but he doesn't spend any time trying to validate it. He just says, This is what I did. And the steps aren't even described, you know, in the way that I

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would describe steps in, say, one of my publications. And I wouldn't consider that validation, even though it's a peer-reviewed outlet, in the same way that when I publish in Operations Research and the algorithm is the feature of the -- the -- the article and then -- like, for instance, I have a paper where the algorithm is a feature. It's in Operations Research journal. At the end, I save maybe three pages where I apply to redistricting.
I wouldn't or I think other people wouldn't then consider, just because that's peer-reviewed by the Operations Research community, that the Operations Research community now has validated my redistricting -- you know, whatever it is I said about redistricting, just like, in the same way, if you publish in Political Science and put the algorithm in a footnote, that's not a validation of the algorithm.
My publication in Operations Research, I wouldn't consider a validation by the Operations Research community that I have these great

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redistricting insights. It's about the algorithm in Operations Research and Political Science. The publications are about something else. It's not about the algorithm.
BY MR. LEWIS:
Q. Dr. Cho, you're aware that Dr. Chen, in this case, created two sets of 500 simulated maps, correct?
A. I am.
Q. And what factors -- we'll take -- he has a Set 1 and a Set 2.
What factors did he consider, based -- you know, based on his report, when creating his first set of the 500 simulated maps?
A. So in his first set, he -- he ensured population equality to one person; he had contiguity; he had avoiding county splits; avoiding municipality splits; and geographic compactness.
Q. And then he ran a second set.
What's the difference between the second set and the first set?
A. The second set added incumbency protection.
Q. And do you believe that these sets are

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appropriate samples to use to compare against Act 131?
A. I do not, because they're not a random set of maps.
MR. GERSCH: Objection. That's not what the report says.
THE COURT: That's not what whose report says?
MR. GERSCH: Dr. Cho's.
THE COURT: You can cross-examine. Objection overruled.
BY MR. LEWIS:
Q. Dr. Cho, did you identify any other concerns with the -- with the samples that Dr. Chen -- I should say the criteria that Dr. Chen used in selecting his sample sets?
A. Yes. So I objected to the -- to the first simulation set because it didn't include all the traditional -- traditional districting principles that were included into the creation of Act 131.
I also objected to a number of maps, all but 54 of them, on the grounds that they were not legally valid maps by either, you know, not complying with the Voting Rights Act or -- or something else that was used to create Act 131.

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Q. Okay. And with respect to --

MR. GERSCH: I'm just going to object here. The testimony was that -- the objection that she stated was that he didn't incorporate the principles that were included in the creation of Act 131.

As Your Honor knows, it's been an enormous source of contention in this case where we tried to find out what they did to create Act 131, and they have asserted the legislative privilege, and Your Honor has sustained them on that.

I don't think she can testify as to what was included in -- used to create the maps in Act 131.

THE COURT: Mr. Gersch, you may be correct. Now, what they may have handed you is an incredible opportunity on cross-examination, because maybe she knows what they used, and she's just testified -- I agree that that was her testimony.

So I'm going to overrule your objection. You'll have an opportunity to cross-examine.

MR. GERSCH: Understood, Your Honor.

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THE COURT: Okay.

BY MR. LEWIS:

Q. Dr. Cho, let's just return very briefly to that -- to that -- to that prior answer.

THE COURT: That doesn't mean he's not going to get an opportunity to cross-examine.

You understand that, Counsel?

MR. LEWIS: Perhaps not.

BY MR. LEWIS:

Q. You're not offering testimony today concerning the precise factors that the Pennsylvania General Assembly used when it -- it drafted Act 131; is that correct?

A. Yeah. This is -- in my opinion, this is what they used.

Q. What this specific legislature would use or what a legislature in -- or -- or traditional districting factors legislators -- legislatures may consider?

A. Traditional districting principles in general, as I understand them. And, also, in this -- in this particular map, the -- the incumbents were drawn into different districts, and that doesn't really happen at random. It's not something that --

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if you notice that all the legislatures are in separate districts, you think, Oh, that's weird. You know, that must have happened at random. To me, when I see that, I think, Oh, that was an intentional -- you know, something intentionally done.

I didn't talk to anyone. No one told me it was intentionally done. It's just -- in my opinion, it seems like -- given that I saw that it -- it happened, and it would be rare to happen otherwise, in my opinion, it's something they used.

Q. Okay. And, Dr. Cho, in political science, what are considered traditional districting factors?

A. So in political science, you know, it's generally understood that, you know, you have to have population equality, contiguity and compliance with the Voting Rights Act. Those are just required by law.

And then there are these traditional districting principles which are -- which are commonly used, and those would be compactness; preservation of municipalities, like cities or counties, communities of interest -- what did I miss?

I said compactness, preservation of cities, incumbency protection, preservation of cores.

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Those come from legal cases. It's something that the political science community who works on this talks about all the time.

Q. Okay.

Okay. And so why, in your view, is Set 1 not an appropriate set of maps to compare against Act 131?

A. Because it left out incumbency protection --

Q. Okay.

A. -- which is constraining, obviously, on what kind of maps are drawn. So -- so if they don't use it, they're leaving out a constraint that the map drawers who used 131 used. And so then they aren't comparable because, then, you're comparing apples to oranges. Right? You have to use the same -- the same constraints.

Q. Okay. Dr. Cho, do you agree with the manner in which Dr. Chen defines incumbency protection in his report?

A. He defines it as the 17 incumbents have to be in separate districts. To me, in political science, our understanding of incumbency protection is not just that the incumbents have to be in different districts. One of the reasons we have --

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one of the reasons incumbency protection is used a lot is, for instance, if you want to get a map passed, a lot of times, you have to satisfy certain people. And sometimes that is -- translates to protecting incumbents, meaning they -- they will feel happy with their district.

And they wouldn't feel happy with their district, for instance, if you -- just -- just because you haven't paired them with another incumbent. They want a certain kind of district composition. And so that affects, for instance, the partisan metrics of the plans that are drawn.

So if a plan is drawn with incumbency protection, that affects the partisan -- the partisan metrics. And so if you leave it out, then you might say, Oh, this was obviously partisanship, when it was, at least partly, incumbency protection.

Q. So in your view, does incumbency protection involve -- involve preserving the -- like, the core constituency of -- of the -- of the incumbent's prior district?

A. That, I think, is usually how incumbents see it, that that -- that's what they want when they're being protected. And I think that is part of -- you know, that's part of the idea, is --

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for the constituents, that, you know, you don't completely obliterate their -- their district.

Q. And is that concept of incumbency protection as you've just testified -- is that generally understood by political scientists?

A. Yeah. That's how we understand it. We certainly don't understand it as just everybody has to be in their own district. It also has to do with the composition of the districts.

Q. Okay. Dr. Cho, I've put up on the screen Petitioners' Exhibit Number 15, which I'll represent to you is Figure 10 from Dr. Chen's report.

Dr. Cho, did you review this -- this figure as part of your review of Dr. Chen's report?

A. I did.

Q. How many of Dr. Chen's 1,000 maps do you consider to be at least potentially useful to compare against Act 131?

A. I would say, at most, 54, the set of maps that are in the Simulation Set 2 on the right. Simulation Set 1, I would knock out because there was no incumbency protection when those maps were drawn.

Set -- Simulation Set 2 is a collapse of the 500 districts -- 500 maps that he drew for that simulation set because only 54 of them preserved

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the same number of black voters in District 2 at 56.8 percent.

And so all the other maps are not legally -- are not legally valid maps. They either violate the law by not -- not -- by violating the Voting Rights Act, or they're noncomparable because they take into account not -- they don't into account all the considerations that were taken into account to draw Act 131.

Q. Okay. Dr. Cho -- and, again, I just want to clarify. You're talking about factors that may have been considered by the legislature.

You're speaking hypothetically, correct, not on the basis of any specific information about how the General Assembly, you know, may have drawn Act 131?

A. Yeah. I don't know anyone in the General Assembly. No one tells me secrets.

Q. Dr. Chen, is a sample size of 54 maps sufficient, in your opinion, to draw strong statistical conclusions about Map 131?

A. No, it is not. I think it's -- this is a point that is -- is -- is nonintuitive. But there are an astronomical number of possible maps that can be drawn. I think Dr. Pegden made reference to in

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his report that it's more than the number of elementary particles in the universe, which would be about 10 to the 86th. It's actually way more than 10 to the 86th.

So one way to answer that, I think -- an example I use all the time is there have been fewer than 10 to the 18th seconds since the universe began, and so you can kind of imagine how long -- how many seconds that -- that is.

So if you wanted -- if there are -- so let's say there are 10 to the 18th possible maps, which would be approximately the number of seconds since the universe began. So if you were to draw a random sample -- let's say it is a truly random independent sample, and you -- it was of size 54.

So you pick 54 seconds at random, and then you say, okay, here's our representation of what's gone on since the universe began. I think that -- that doesn't make any sense at all.

You obviously have drawn some information. To be able to understand that large of a population with 54 units is impossible or unreliable.

Q. Okay. Dr. Cho, why isn't this like a question where you would say, If I flip a coin a

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thousand times, why would I need to flip a coin 1,001 times to understand the likelihood of drawing heads on any particular coin flip?

A. So for a coin, a thousand flips would be perfectly fine. You can understand a lot about a coin with a thousand flips. In fact, you could do extremely well understanding the coin with a thousand flips. And that's because a coin -- the outcome of a flip is either heads or tails. So there are two possible outcomes.

So you do it a thousand times. You notice whether it's Outcome Number 1 or Outcome Number 2. You would gain very little from tossing a coin one more time than a thousand.

But for redistricting, there aren't two outcomes. There's -- there's an astronomical number of possible maps with many different outcomes on many different facets that someone might be interested in.

And so to say I have a thousand maps is completely different from saying I flipped a coin a thousand times, because it's -- it's -- it's not even the same thing.

Q. Okay. And, Dr. Cho, in your opinion, what -- what conclusions can we draw from -- from this case from the sample of the -- the 54 maps that

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we've been discussing?

A. In my opinion, these 54 maps are not a random sample, it's not a large sample, it's not an independent sample. In my opinion, there is no reliable conclusion that we can draw from these 54 maps about what is possible in -- in redistricting.

Q. And, Dr. Cho, I'd like to return very briefly to a concept that, you know, you discussed earlier about, you know, adding constraints onto a model.

As you were reviewing Dr. Chen's report, did you notice anything about how the addition of constraints affected his results?

A. Yeah. One of the things I notice is -- so in Simulation Set 1, he doesn't have incumbency protection. In Simulation Set 2, he does. That's an additional constraint.

And one of the things that you'll notice in his plots, for instance -- I was going to refer to the one you just had up that you took down, but . . .

Q. All right. I'll put -- I'll put it back.

A. One of the things you notice is every single one of his plots from Simulation Set 1 to

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Simulation Set 2, the ones in Simulation Set 2 are more Republican-leaning. So, for instance, in this plot in Simulation Set 1, he has the -- the number of districts at nine, and in Simulation Set 2, he's added one -- 10 is the most common, but 11 is -- is second-most common. And then he has a 12, whereas in Simulation Set 1, that wasn't -- wasn't possible.

And if you look at all those other maps, whenever he goes to Simulation Set 2, it has more of a -- a Republican leaning. And in my opinion, this shows up because what he's doing is he adds additional constraints, and many of them have to do with political geography.

So, for instance, when you -- when you -- when you preserve cities, the map becomes more Republican-leaning. And that, I think, comes from his own work, where he says political geography is constraining in such a way that in -- in most states, that translates to a -- to a Republican bias, as it were, because Democrats are inefficiently distributed by where they live.

So because you impose these other constraints, they -- the map becomes more biased against Democratic representation.

Q. And that -- what you describe as -- as

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bias is -- is the result of factors other than a partisan intent on the part of the legislature; is that correct?

A. Yes, that would be correct.

Q. Dr. Chen talks about -- in his report on Page 17, he talks about how he -- he believes that a valid plan with only 16 -- I'm quoting out of Page 17 -- with only 16 or fewer counties split can be easily accomplished without difficulty and without sacrificing other nonpartisan districting criteria.

Dr. Cho, do you agree with Dr. Chen's assertion to that effect?

A. I didn't understand Dr. Chen's assertion there. He didn't define his terms. I don't know what "easily accomplished" means.

It -- you know, for instance, he says, 16 or fewer counties is easily accomplished. To me, the implication there was that if you can easily accomplish it, you should easily accomplish it. It just should be done. And this plan splits more counties, so, you know, it must have been something -- something else going on.

He never defined "easily accomplished." I don't know what that means. I don't know if that means his computer found them quickly, his computer

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found a lot of them, his computer -- I just don't understand that whole concept, because a computer finding something easily -- you know, if I write a better algorithm, I can find other things easily. If you write a bad algorithm, you can't find them easily. But these maps, they all exist, so I don't know what it means to find some easily and find some not easily.

You know, for instance, if I use my supercomputer and I have a lot more computing power, I can find other things easily that you couldn't find easily. So I don't know what defines "easily accomplished." It's just not -- it wasn't a term that was -- was -- it was an ambiguous term to me.

Q. Okay. And, Dr. Cho, I'd like to call attention to Figure 3 of your report, which appears on Page -- let me make sure I get this right -- the top of Page 25 of your report.

We have a version of this as well in -- in LR-12.

Can you describe this figure to us, Dr. Cho?

A. Yeah. The one on the left was his -- I think it was Figure 6, but I don't remember -- but it's from his report. And then the -- all the

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colored annotations there are mine, except for the Act 131, which is his. But the blue and green are mine.

So he presented this plot to show that Act 131 is so far away from the maps that he created. And so when I look at this plot, you know, it looks far away to me, too, because there's this big -- this big chasm there where the blue oval is, like, there's nothing there. It's like, oh, it's so far away.

But we all know that there are maps that split 22 counties, split 24 counties, split 21 counties. And then if you can easily split 16, you can even more easily split 24 or 25. I mean, there are maps everywhere on this plot. They're just not all there. They weren't all in his -- in the set that he wanted to -- to show.

And the way he draws it, they look like his maps and Act 131 are -- are at the opposite ends of something. But my plot on the right says, okay, you could go from zero to 60 on a -- you know, 60-some on the number of counties split, and you can go from zero to -- is it 2,562, something like that? -- more than 2500 split municipalities.

So the number of split municipalities in this -- in Act 131 is at 97.3 percent. It's high.

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And I think if you plot it like I plotted it, you can see it's high.

They've preserve most of the municipalities in Act 131. So the fact that he can preserve another one, to me, it's like that's the same thing. If you can preserve 97.3, you can preserve 96.31. I don't know that that needs to be done, if it can be done or even if it can easily be done. I'm not sure what that means.

But the way he has it presented, I think, by leaving all that space where I have the blue oval -- where I have the blue oval, leaving all that space empty, to me, it was clear that he was implying his maps are -- are constitutional, and then there's this set of nothing, and then there's unconstitutional Act 131, which is not clear to me.

I mean, it's -- it's -- to me, it was clear that it was -- what he was trying to say, but it's not clear that that is actually true, because he's leaving so much out.

You know, why did you leave out all these other easily accomplished maps that could be there? And then, for municipalities, he says 66 municipalities are easily accomplished. In fact, very -- there's a lot of maps where 66 municipalities

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are -- are easily accomplished. But then he has nothing for 67.

It's like, so in your set, 66 was so easily accomplished that you have so many maps there, but there's no map at 67? And then the -- the Act 131 was at 68. I don't -- to me, the way it's presented is very misleading. It doesn't show what -- what is actually -- it's a stylized interpretation, it's a stylized presentation intending to show something which is not -- is not in the data.

THE COURT: Counsel, can you please let me know when you're at an appropriate break point?

MR. LEWIS: Now would be fine with me.

THE COURT: Okay. Let's take a 10-minute break.

MR. LEWIS: Okay.

THE CLERK: The Court is now in recess.

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(Whereupon, a recess was taken from 11:16 a.m. to 11:39 a.m.)

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THE CLERK: Ladies and gentlemen, Court is now in session.
THE COURT: Please be seated, everyone.
You may continue your examination.
MR. LEWIS: Okay. Your Honor, we did want to bring one point -- one point to the Court's attention before I consider -- before we continued, and that is Legislative Respondents do not plan to call Dr. Gimpel. We're withdrawing him as a witness in this case.
THE COURT: Okay.
MR. LEWIS: The consequence for that is that when we're done with Dr. Cho, our next witness will be Dr. Nolan McCarty, and he's not going to be available till Friday morning. So we may have to take a -- take a recess.
But he's going to be our only witness, and we don't -- there's virtually no chance that he's going to take all of Friday.
THE COURT: How -- how -- how did we resolve the agreements between counsel

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over other fact witnesses? What is it the status of that?
MR. LEWIS: I'll have to have others address that question.
MS. HANGLEY: The Executive Defendants, minus the Lieutenant Governor, is resolving that. We'll submit an affidavit.
THE COURT: You're submitting the affidavit when?
MS. HANGLEY: We can -- we can submit it today, Your Honor.
MR. LEWIS: Legislative Respondents have seen the draft of it, so we're all aware of it.
THE COURT: Have Petitioners seen that?
MR. GERSCH: Yes, Your Honor.
MR. LEWIS: Everyone is e-mailing everyone.
THE COURT: Okay. So Executive Branch, minus Governor, are going to present how many affidavits?
MS. HANGLEY: One, Mr. Marks.
THE COURT: And you're just going

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to file them?
MS. HANGLEY: If that's acceptable, Your Honor.
THE COURT: Does anyone have any objection to just having them filed, as opposed to -- they will be in the record --
MR. GERSCH: No objection.
THE COURT: So just file your affidavit in the record.
MS. HANGLEY: File the affidavit or submit it as an exhibit?
THE COURT: What do you prefer?
MS. HANGLEY: As an exhibit.
THE COURT: Okay. You can do it either way. I'm not going -- if you want to do it as an exhibit, we'll do it as an exhibit. If you want to PACFile it, that's fine, too. But we can do it as an exhibit.
It's all going to the Supreme Court, so either way.
Mr. Tabas.
MR. TABAS: The Intervenors will be submitting two affidavits that have been approved by all of the parties. They will be submitted tomorrow. They're in the

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process of being executed.
THE COURT: Okay. Just so we're consistent, we'll do that as exhibits as well. Okay.
MR. PALNICK: Your Honor, Lazar Palnick for the Lieutenant Governor.
We are -- we have an agreement from everyone but the Legislative Respondents, and we just conferred and said that we hope to resolve that difference as soon as we break for lunch --
THE COURT: Okay.
MR. PALNICK: -- and we will also put in the affidavit of the Lieutenant Governor as an exhibit.
THE COURT: Okay.
How do we plan to fill the time this afternoon, I'm wondering?
Petitioners have anything to offer?
MR. GERSCH: Do we have a -- I'm sorry. This afternoon?
THE COURT: Yes.
MR. GERSCH: No. We'll -- we'll rebut at the end of their case.
MR. LEWIS: Your Honor, we did

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attempt to get Dr. McCarty here today. It was just an impossibility. He has a commitment, and we could not get him --

THE COURT: How long is Dr. McCarty's testimony going to take tomorrow?

MR. LEWIS: Can I phone a friend?

THE COURT: Sure, but your friend has to come up to the podium.

MR. LEWIS: Yes, sir.

MR. TUCKER: Good afternoon, Your Honor. I guess I don't get a break out of being up here today, but I don't anticipate the direct testimony taking much more than two hours with Dr. McCarty.

So assuming we're starting at 9:30, I think we would be done with the direct before lunch.

THE COURT: Okay.

Do you want to hang up here, or --

MR. TUCKER: I'm happy to go in the back.

THE COURT: Okay. Go in the back.

Mr. Gersch, how long -- I understand you haven't heard all of the expert

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testimony in this case. Rebuttal cases are usually pretty brief.

How long do you anticipate you will take on Friday for your rebuttal case?

MR. GERSCH: Your Honor's right that in the absence of having heard -- I mean, we've heard just the beginning of one of their two experts --

THE COURT: Oh, I thought we were almost through.

MR. GERSCH: I don't think so --

THE COURT: Oh, okay.

MR. GERSCH: -- but it's not my witness.

So it's hard to say. We understand what the time constraints are, and we, too, want to conclude earlier rather than later in the day on Friday so that we can get to the task that the Court has assigned us in terms of posttrial briefs. So we're going to make every effort to be -- to move things along.

THE COURT: Okay.

And I understand it was an unfair question, so I appreciate your -- your

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efforts to respond to the unfair question.

MR. GERSCH: No questions from the Court are unfair.

THE COURT: Sometimes they are. The good news is I get to decide which ones are fair and unfair.

MR. GERSCH: Of course, as it should be.

THE COURT: Okay. Well, I appreciate -- I appreciate the withdrawing of that witness, and we'll just proceed as we can to -- to finish up this trial.

So why don't you proceed with your current examination?

MR. LEWIS: Thank you, Your Honor.

BY MR. LEWIS:

Q. Dr. Cho, I just want to summarize, if I can, your -- your basic conclusions about Dr. Chen's report and his conclusions in this case.

Dr. Cho, in your opinion, do you believe that Dr. Chen's simulations have actually established that partisan bias was the predominant motivating factor behind how the legislature created the 2011 Plan?

A. No, I do not.

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Q. Do you believe that Dr. Chen's simulations are accurately measuring partisan bias in Pennsylvania's districting in the 2011 Plan?

A. No, I don't believe they are.

Q. Okay. Dr. Cho, you also reviewed the report of Dr. Wesley Pegden in this matter; is that correct?

A. That's correct.

Q. Dr. Cho, are you familiar with Dr. Pegden's academic writings?

A. I'm not familiar with all of them, but I am familiar with the one that is brought up in this case.

Q. And, Dr. Cho, are you familiar with a Markov chain?

A. Yes, I am.

Q. Okay. Can you describe a Markov chain?

A. Yeah. A Markov chain is a process that has what we call the "Markov property." And that is basically that given a state of where you are, that state can be determined by the previous -- can be completely determined by the previous state -- that's the Markov property -- so that it doesn't matter what the previous states were to -- to that previous state; it only matters what the previous state was.

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Q. And do you work with Markov chains in your -- in your research?

A. I teach about Markov chains. I teach MCMC. I teach about Monte Carlo. I have used Monte Carlo in my research. I've actually never had an application of MCMC that I've published.

Q. Okay. Dr. Cho, what role do Markov chains play in -- in an analysis of districting maps?

A. So I explained, I think, previously that MCMC can be used to explore the space of possible redistricting maps. And I think I explained that it's theoretically possible to characterize the -- the set of possible maps using MCMC.

The main problem there is, I think I said, it's theoretically possible but practically unobtainable, because the computational power required is -- is -- is more than we -- we have, currently.

So that is -- that is the role -- it's theoretically a very -- a beautiful way of thinking about the problem, but it is just not practically obtainable right now.

Q. And, Dr. Cho, you mentioned two related -- what I think are related terms: one is a Markov chain, and second is a Markov chain Monte Carlo.

Can you elaborate on the difference between the two?

A. Yeah. So a Markov chain Monte Carlo incorporates a Markov chain in a Monte Carlo -- that wasn't a very good definition, was it? That's why it's called Markov chain Monte Carlo.

But the idea there is -- I think the key to what we're talking about is for an MCMC to work in the context of redistricting or anything else, it's required to do what we call "mixing." And mixing means it's reached a point at which -- the point at which you -- you achieve mixing is where the Markov chain starts to produce the -- that -- that sample -- that representative sample.

So the problem with MCMC in the context of redistricting is something that Dr. Pegden and I agree on, which is you have no idea when the MCMC will achieve mixing. And in all practical purposes, it won't achieve mixing for the applications that we're talking about, for redistricting, because the application is so large.

For smaller applications, you can use MCMC, and it will do exactly what -- what I'm saying it will do.

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Dr. Pegden, in his report, didn't do an MCMC; he did -- he just ran a Markov chain.

And so in MCMC, there are requirements of the Markov chain. So, for instance, it has to be irreducible, aperiodic, positive recurrent. So if it has certain properties -- and the state-space you can define to have certain properties, for instance, that it's path-connected -- then MCMC will work.

So there are conditions under which MCMC will and will not work, but for -- for the Markov chain, which Dr. Pegden uses, he relaxes a lot of these requirements. First of all, it's not a Markov chain Monte Carlo. He's not claiming that he's producing a representative sample of maps. He produces what he calls a Markov chain that has only the proper -- the property that it's -- it's reversible, which means it can get back -- it goes forward to a state, it can get back from that state.

This is not as restrictive as what you need for MCMC to work, and so he is not able to draw the same conclusions that you can -- you can draw from -- from MCMC.

But he -- he has a theorem that says that if you run a -- a reversible Markov chain, that you can determine, without mixing -- without anything

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mixing, whether or not a certain observation is an outlier.

Q. Okay. And are you familiar with the algorithm or property that Dr. Pegden describes in his expert report --

A. Yeah --

Q. -- or his approach, I should say?

A. -- I read both the paper and the expert report, yes.

Q. And how does Dr. Pegden's Markov chain approach -- how can it apply to a redistricting problem?

A. So the idea of what he wants to do is he wants to say that if he -- if he starts his Markov chain at the current map, he -- he walks -- which is what a Markov chain does, it produces a random walk -- around the current map, and then he says if he can -- if he can walk a sufficiently long time, that he can make a statement about whether the current map is -- is it an outlier or is not a current outlier.

He's unable to put it into a distribution, say, but he's able to say, at least, that it is an outlier. That's his intention.

Q. Okay. So let's unpack that concept a

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little bit. So you talk about taking a walk.

So can we maybe use an analogy of, you know, like -- like -- is it sort of like walking through a city, for example?

A. It's not exactly like walking through a city, but sometimes, when I explain things to my family, it -- or other people at Thanksgiving or Christmas, I say things like that.

Q. Okay.

All right. So can you give an example of how -- of how this -- this approach would -- would tackle a problem of deciding if one observation is unusual among a large set?

A. The way Dr. Pegden does it is he starts his Markov chain at the current map, and he defines the set of possible maps within a graph theory framework, which basically means all the units are vertices, and whether they are connected or not, are the -- are the edges of -- of this graph.

And he -- he -- he basically looks at whether a -- a VTD is connected to another VTD -- is on the boundary of two districts. And then a -- a step in his algorithm would be to switch a VTD from one district to another district. That would be -- that would be a step. And so another step

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would be after he gets to that step, he will switch another one, which he chooses at random, to get to the next one.

So that is his walk. And he -- he wants to use this walk to say that the current map is or is not an outlier.

Q. And, Dr. Cho, I draw your attention to Figure 1 of your report, which appears on Page -- Page 8 of your report.

Can you describe what this figure is?

A. Yeah. On the left is a figure from Dr. Pegden's paper, and on the right is -- is my figure.

So on the left, he's explaining -- and he has a caption there where he is explaining that -- so in this instance, the green dot with the black circle around it, which is among all the pink dots, that would be his current map. That's -- that's what he's -- what he's illustrating there.

And the green map -- the idea there is it's different from the pink maps. Right? It might be like the other green maps, but it's different than the pink maps.

So it is a local outlier. So if he starts there and he walks around and -- and by "walk"

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here, we're saying you can walk to things that you are -- you are connected to. So if there's a line between you and another circle, you can walk to that circle. And -- and in this context, those other circles would be different maps.

So what he's saying there is that any -- any observation has the same likelihood of being a local outlier as any other observation. And so that allows us to say, If I take a walk from any particular place and observe whether or not where I walked from is very different from where I'm walking to, then I can make a statement about whether or not it's -- it's an outlier.

And he says in the caption he can say to an unusual degree this state is a local outlier. This is his test.

So on the right, what I'm trying to illustrate is that what he's doing is he's saying in the context of redistricting, it's a local outlier, which means -- I have that arrow to this other plot with the little black square. So I'm saying that thing is -- is a really small portion of the actual space of possible redistricting maps.

And he and I would agree there. He basically says that in his report -- he does say that

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in his report.

And so I have those black arrows to -- to the right there, and I'm basically saying this space goes on for a long time. It really goes on for a really, really long time. And he's searching only this little piece of that very large space, so that if -- if it's a local outlier, meaning it's very unusual compared to what's around it, that really doesn't say that much about what's -- if it's a global outlier in the entire space of -- of maps.

Q. Okay. So just to make sure I understand what you're saying -- so the principle behind -- as I understand, what you're saying is the principle behind the local outlier -- that if you look at the green dot in the center -- and, Dr. Cho, I think you have a laser pointer, if it would help. I don't know if it's back there or not.

A. I don't think it's here.

Q. So in the Markov chain, you're saying that the -- if you walk from the green dot in the middle, what direction -- you know, what directions can you take?

A. Yeah. You can go to your immediate neighbors. So you have four immediate neighbors in this -- in the way that this one is set up.

1207

For the way Dr. Pegden set it up, there are a lot more immediate neighbors, because anything that's on a border between districts would be -- would be what we call a "neighbor" -- a "neighboring map."

THE COURT: So does that mean there's eight possibilities to move to?

THE WITNESS: No. So if you have -- so there's 18 districts, and so anything that is a border between two districts, all of those VTDs can be swapped. So those are -- those are all neighboring maps. So there's lots of neighboring maps.

BY MR. LEWIS:

Q. So, basically --

THE COURT: I'm just trying to understand the -- your testimony with regard to the left chart is a -- the green dot in the middle, as I understand it, is the 2011 Plan in Pennsylvania.

THE WITNESS: So this is his -- this is his illustration of how it works, this is not his illustration of the redistricting.

So in this example the green dot has only four neighbors.

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THE COURT: But I see -- but I don't understand the neighbor concept. I see there are -- there are -- are -- again, I'm not a mathematician, but there are eight pink dots around a green dot.

Wouldn't that suggest eight neighbors?

THE WITNESS: Only the ones that have a line connected -- only if it's connected with a line. So the ones in the corner, you have to go two steps.

THE COURT: It's not like Connect 4; it's more like Checkers or something? You can't go diagonally?

THE WITNESS: Yeah. You can only go where there's a line.

THE COURT: Okay. Okay. That helps.

Okay.

BY MR. LEWIS:

Q. And so in your opinion, Dr. Cho, what's the problem with general -- generalizing for the entire distribution of -- of redistricting maps based on -- on this local-outlier approach?

A. The problem is it's a local outlier --

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MR. GERSCH: I'm going to object here, Your Honor. I think when I was doing voir dire, Your Honor pointed out that the questions hadn't been asked yet. Now we're getting to the question that raises the issue of the connection between Dr. Cho's qualifications and what she wants to say here.

What she wants to say here and what's in the report is she wants to argue against the theorem, the theorem that Dr. Pegden has been proved and that nowhere, nowhere in Dr. Cho's report does she say is not proved. And, in fact, Dr. Pegden's theorem all -- makes almost no appearance in Dr. Cho's report.

I don't think she's allowed to argue against the theorem. I should strike "think." She's not allowed to argue against that, Your Honor. So we object.

THE COURT: Counsel?

MR. LEWIS: Dr. Cho is qualified as an expert if this field. She's testified to -- to teaching about Markov chains and teaching about the application of these

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principles. She's researched these computer simulations and -- and various statistical and other models for examining redistricting for over 20 years.

We think she's more than qualified to talk about the limitations of a particular approach to analyzing a redistricting problem.

If counsel wishes to cross-examine, of course, he's more than welcome. And perhaps it goes to her weight; it does not go to her fundamental qualifications --

THE COURT: Mr. Gersch, sit down. Please finish, Counsel.

MR. LEWIS: That was my statement.

THE COURT: Okay. As I understand Dr. Cho's testimony is she's being -- she's opining as -- not as to the theorem itself and its validity, but as to its application to the redistricting concept, particularly here. I think that is -- I don't think she's -- I haven't heard her challenging the theorem, specifically, only its application in redistricting matters.

Is that correct?

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MR. LEWIS: That is correct, Your Honor.

THE COURT: Okay.

So the objection is overruled. I believe that's within the -- within the scope of her expert testimony.

MR. LEWIS: Okay.

BY MR. LEWIS:

Q. So, Dr. Cho, in your -- in your -- on the basis of your expertise, what -- why do you believe that -- or do you believe that this -- that this approach allows you to draw -- the application of this approach to redistricting allows you to draw conclusions about where a given map may lie in the distribution of possible maps?

A. So I'll clarify that on -- on -- on that other point, which is I'm not challenging the theorem. The theorem is fine. As a mathematician, someone who reads math all the time, it's perfectly fine with me.

It's a very interesting result. It's a very interesting take, and my opinion is on how that approach applies to the redistricting problem.

And Dr. Pegden and I agree on most of his report. I think what we disagree on is that I

1212

think his claims are overbroad in the context of redistricting.

In the context of math and how he presented the proof, it's perfectly fine.

Q. So can this local -- what, in your view, is -- is a limitation of this -- this theorem as applied -- as -- why, in your opinion, in the redistricting context, are we not able to draw a conclusion that if the green dot in the middle -- and I realize that this is just an illustration, but if the green dot is not like the pink dots in the local sample, why, in your view, is it not possible to then draw the conclusion that the green dot in the middle is unlike the dots in the entire distribution that you have on the right-hand side of your figure?

A. I think what -- what I want to say in the report -- what I said in the report is that Dr. Pegden's approach doesn't meet the rigor of the law. He tries to apply it to redistricting, but if you apply something to redistricting, you can't just do it as you wish; you have to follow the law; you have to follow what a legally valid map is; you have to understand how redistricting works.

And he understands that it's an astronomically large state-space. He and I agree on

1213

that. He's the one that said -- that gave that 10 to the 86th number. We agree on that.

We also agree on his -- his theorem. I think it's really interesting. I think it's, you know -- it's interesting. It's -- I thought -- when I read it, I was like, Oh, that's interesting. But it doesn't -- it doesn't apply to redistricting in the way that he thinks it applies to redistricting. And I think part of that is his -- he doesn't work in redistricting. He doesn't really work on this problem outside of that -- that application.

He understands it's a big space, but he doesn't talk about the limitations. The things he says are overbroad. That's -- that's the essence of my report.

THE COURT: Counsel, can I interrupt with trying to move this along with a very straightforward question to Dr. Cho?

MR. LEWIS: Absolutely.

THE COURT: Dr. Cho, why doesn't this work in redistricting?

THE WITNESS: So what he identifies -- and he calls it this -- it's a local outlier. Right. He traverses the

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space of maps around the current map, and when he does that, he makes every step, so he makes a trillion of them, approximately. Every step is a switching of one VTD.

So when you switch one VTD, I think if we put up a map and we looked at the VTDs and you think, Okay, here's the current map -- if I switch one VTD, have I really moved away from the current map?

You really have not. It's -- it's essentially the exact same map. And I don't think anyone would -- would object, you know, to -- to that, right? If you switch one VTD, maybe there's a critical one here and there that people might reject to; but, in essence, it's the same map, right?

But the way he defines the problem, he defines it in such a way that even the change of one VTD has this mathematically significant difference because of the way he wants to measure it. And it is -- it can be mathematically different but yet the exact same map.

And so all those little differences, they don't -- they don't matter, even though

1215

he says it matters. And you can say mathematically it matters, mathematically it's a different value, but it -- actually, it's not. It's the same thing. For someone who is redistricting, who thinks about redistricting, if you switch one VTD, it's the same thing.

And he does this a trillion times. And he, himself, says in his article, even after a trillion moves, which sounds like a lot of moves, because we don't usually deal with a trillion, a lot of the maps -- if you look at them, they're essentially the same map; you look a -- you look at it visually and you say, Oh, a trillion moves; it hasn't -- is not really that significant.

And part of that is because it's a trillion moves -- I don't think it's a trillion maps, because a lot of these moves violate some -- something about the law. Either it's no longer, you know -- the population deviation is now not satisfied or, you know, it violates some -- something you don't want to violate.

So not all the moves

1216

actually translate into a map. Some of them are maps. Some of them are not maps. The ones that are maps, a lot of them look exactly the same as the current map, so even if you say it's worse, it's -- it's the same map.

So, you know, a lot of these things, they work out mathematically, but when you -- if you're actually a districting person, you think about the maps, what they mean, how far have you moved. It's -- it's completely different than the -- like, the math concept of, I've got a different value.

THE COURT: Okay. Thank you.

BY MR. LEWIS:

Q. So, Dr. Cho, maybe we can use an analogy.

So this approach, we'll say if you happen to visit a restaurant in a neighborhood in the city and that restaurant is just a bad -- it's just not a good restaurant, you don't like that restaurant, and you want to ask the question, you know, How bad is this restaurant relative to all the restaurants, for example, in a neighborhood, how would -- how would the -- Dr. Pegden's approach

1217

address that question?

A. So in -- in that analogy, he would -- he would begin at the current restaurant. That would be his starting point. And then his Markov chain would walk around the neighborhood and say, How about you? Are you a bad restaurant? How about you? Are you a bad restaurant? And if all the other restaurants in the neighborhood are worse than his restaurant, then he would say, You're a bad restaurant, right; you're -- you're an outlier; you're -- maybe you're the worst restaurant.

But to take that to the context of redistricting, even though you're the worst restaurant in the neighborhood doesn't mean you're the worst restaurant. You know, if you -- if your question is, you know, Is this a really bad restaurant, well, maybe you're in a really posh neighborhood and the really bad restaurant in that neighborhood, this is not a bad restaurant; it's actually quite a good restaurant.

So if you look at all the restaurants, like, say, in the world, you say, Oh, I didn't look at all the restaurants in the world; I only looked at the restaurants in this neighborhood; it's a really bad restaurant in this neighborhood, but I don't know

1218

if it's -- if it's a really bad restaurant in the broad stream of bad restaurants, what it means to be a bad restaurant.

MR. GERSCH: Your Honor, I know what the Court's ruling is going to be. I just want to restate my objection. She is now arguing with the theorem.

THE WITNESS: No, I'm not.

THE COURT: Dr. Cho, that was an objection, and I've got to -- I've got to jump in.

THE WITNESS: Can you say I'm not?

THE COURT: So, again, I believe she's testifying as to the theorem's applicability to redistricting. So I'm going to overrule the objection.

I actually think she likes the theorem. But -- you know, so overruled.

MR. LEWIS: Thank you.

BY MR. LEWIS:

Q. So what, in your mind, is -- is idiosyncratic or unique about redistricting that limits the application of this theorem?

A. So one of the limitations is the way he defined what's a valid map is not, in my opinion, the

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right way to do it because he leaves out -- for instance, kind of like Dr. Chen, he leaves out incumbency protection. But Dr. Pegden leaves out even more. He left out preserving cities. He didn't preserve population equality at the same level that the current map preserves it at. He uses 2 percent. Current map is at zero. He tried 1 percent. The current map is at zero.

So we're comparing something else, because if you're constrained to have population equality and then you say, Okay. The maps I'm going to compare to constrain it at a different level, it's like, Well, do you -- do you get some partisan effect from that, you know, relaxing of that constraint; do you get some partisan effect from not preserving cities?

And he, himself, said in his report, you know, if you don't preserve cities, you might think something's a gerrymander when really it was not. And that's actually his quote, really it was not.

But he, himself, then, also doesn't preserve cities. And I think part of that is, you know, these things aren't magic. You can't just do it. These things are hard to implement. How to work

1220

this into your algorithm so you preserve cities, that's nontrivial. And -- and how to preserve population equality, that's actually quite difficult.

I write algorithms to do that. I know it's hard. It's hard to do. We spend a long time thinking about these things, how to do them. And I think the way he has set up his algorithm, he can't even preserve population equality at zero. He actually cannot the way he set up his algorithm. It's not to say that there aren't maps that way. It's to say that his algorithm, the way he has it set up, cannot do that.

So, you know, a lot of this is not -- is it -- is his algorithm -- is his theorem beautiful? I actually really like his theorem. I mentioned it to my kids. I said, Hey, look at this. Isn't this -- it's really interesting, isn't it? And we talked about it. I was like -- I think, you know, blah blah. And my kids were like, Oh, yeah. That's what they say to me.

But it -- it's -- it's -- you can have something that's mathematically rigorous and beautiful and not be able to apply it well to redistricting, just like MCMC. MCMC is theoretically beautiful. It's really a nice theorem. It's really

1221

clever. It's really -- I really like it. But how to apply it to redistricting, I don't know how.

Neither does Dr. Pegden know how. He mentioned that himself. I mean, I think he would just use MCMC if he knew how to do it. He doesn't know how to do. I don't know how to do it. It's a subject of research.

Q. So to return to the restaurant analogy, to the best I can here, you mentioned that, you know, if this algorithm -- Dr. Pegden's approach can tell you if -- if a map is -- or excuse me -- if a restaurant's a bad restaurant in the neighborhood and -- and what does it say about the world.

You had -- I apologize I can't zoom this in a little bit more.

MR. LEWIS: So this is just purely a demonstrative. We're not going to seek to admit this into evidence.

THE COURT: What is it?

MR. LEWIS: So this is --

BY MR. LEWIS:

Q. Dr. Cho, can you kind of explain what this demonstrative is?

A. It looks like, to me, that --

MR. GERSCH: I'm just going to

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object -- objection: we've never seen this before.

This is direct.

THE COURT: This is what?

MR. GERSCH: Direct. It's their case. This should have been turned over.

THE COURT: It's a demonstrative.

THE WITNESS: I didn't create it.

THE COURT: Can you lay a foundation on your demonstrative exhibit that you're showing the witness? Because all I see is -- I'm not -- there's mathematicians in the room. I'm not going to try -- this reminds me of something I studied in economics in college, but, otherwise, I don't know what it is.

So why don't you explain what demonstrative exhibit you're offering your expert?

MR. LEWIS: Absolutely. Absolutely, Your Honor. So . . .

THE COURT: What is it a demonstrative of?

MR. LEWIS: I think the concept is --

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THE COURT: I don't want to know "I think." I want to know what it is. This is an exhibit that you're offering.

What is it?

MR. LEWIS: It's just a demonstrative.

THE COURT: What is it?

MR. LEWIS: We're just looking at a bell curve around -- with zero being the median -- just a hypothetical bell curve with a smaller bell curve in red underneath it with a much smaller range, and we were just going to use it to try to describe the problem. It illustrates --

THE COURT: Your demonstrative is an exhibit -- it is a large bell curve with a small bell curve inside it?

MR. LEWIS: That's correct.

THE COURT: Okay.

MR. LEWIS: We're just -- if we can hand draw it, we would, but we don't have an Elmo over there, so that's why --

THE COURT: So the demonstrative is a large bell curve with a small bell curve inside it.

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MR. LEWIS: That's right.

MR. GERSCH: Your Honor, again, our objection was simply that it wasn't turned over. We turned over all of ours.

THE COURT: All of your demonstratives?

MR. GERSCH: Yes.

THE COURT: That was nice of you. I'm going to allow him to proceed with the examination.

MR. GERSCH: Understood.

MR. LEWIS: Thank you.

BY MR. LEWIS:

Q. So, Dr. Cho -- so I can understand, so a local -- if you're measuring a distribution range around a local outlier, how would that factor in here?

A. Yeah, I think the idea is the -- the red bell curve.

So I didn't draw this, but the way I would interpret this to be consistent with what I just said is that the red bell curve, let's say the real answer is -- is zero, so you notice that zero is an outlier on this red bell curve. This would be the set of things that you looked at, right, and you say,

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Oh, look, I got the -- the thing that I'm trying to benchmark it on is zero, and zero is -- is superunusual for the things that I found, but you didn't look at what's under the blue one, which is the true distribution of all the things that you could have looked at. And so even though you, using a method, say this is an outlier, it actually may not be an outlier at all.

Q. Okay. And the -- and how does that type of concern about the local versus the global outlier apply to the redistricting problem that's -- that's before this Court?

A. Before this Court, I think what we want to say is this is an unusual map among all the maps that could exist. We're not trying to say this is an unusual map compared to some smaller set of maps that also can exist but is a smaller set.

Q. Okay.

Okay. So I think I heard in one of your prior answers that you had some concerns with what Dr. Pegden refers to as his bag of alternatives.

Dr. Cho, in your opinion, is it important that the criteria for including a particular districting, a particular district map in the bag of alternatives, that Dr. Pegden's theory --

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or theorem would be used to -- to analyze, be consistent with the constraints that are, you know, traditional districting criteria and legal requirements that mapmakers must consider?

A. Yeah, so I did mention this before, that if you're going to compare a map to another map, you need to employ the same criteria that -- that the other map employed.

So, for instance, the other map preserved 97.3 percent of the municipalities. So, again, I was not privy to any secret that they were trying to preserve municipalities, but if they preserve 97.3, to me, it implies that they were trying to preserve them. Because that doesn't happen by chance. It just -- you know, if you're preserving that many, in the current map, they probably tried to do it.

So the same thing with incumbency protection, and Dr. Pegden doesn't put either of those things into his -- into the maps that he -- he compares to.

So the current map also has his 0 percent population deviation, which is -- you know, obviously, someone tried to do that. That doesn't happen by chance. And Dr. Pegden also does not do

1227

that, for instance.

Q. Right.

Okay. Dr. Cho, do you understand why -- how -- let me rephrase.

How might the decision to omit the criteria -- for example, if there was a traditional districting criteria of minimizing municipal splits, how might the omission of that criteria affect the analysis of -- that Dr. Pegden performed?

A. I think I mentioned this one already. He, himself, says, if you don't -- if you don't preserve cities, then you might think that they're -- that -- actually, I can read from his thing -- political geography might conceivably give a false impression that a districting was drawn with bias whereas it really was not.

So he thinks so, too.

Q. And just -- just to clarify, Dr. Cho, you said you were reading from something of Dr. Pegden's.

What were you reading from?

A. That's from his report, Page 5.

Q. Thank you. I just wanted to make sure we had that clear.

And, Dr. Cho, if Dr. Pegden had

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considered for inclusion in his bag of alternatives maps that satisfied a traditional districting principle of incumbency protection, particularly incumbency protection as it's generally used in political science and generally understood in the field of political science, how might that have affected his results?

A. I think, generally, that would include a -- a -- it has a partisan effect. So it would affect the partisan metric.

Q. Okay. Dr. Cho, what would the -- you know, Dr. Pegden has -- has indicated that he believes it's -- it's reasonable to perform an analysis against a -- of Act 131 against a -- a bag of alternative districtings that contain districts that have, in most instances, two and, in a few instances, 1 percent population deviation.

In your opinion, Dr. Cho, was that a reasonable choice for Dr. Pegden to have made for this analysis?

A. It's a choice. I think that what -- what happens when you make a choice like that is now you're comparing apples to oranges and so you have to -- if you want to then say it's an apples-to-apples comparison, you have to somehow

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justify why you -- why you're creating oranges, basically.

And he -- I don't think he really does that. I think a lot of the things that he -- a lot of the deviations that he made were for either mathematical reasons or for "it's really hard to incorporate this into an algorithm," and I -- I totally understand that, because it is really hard to incorporate some of these things into an algorithm. But I -- I think that -- that then affects what -- what you get out.

Q. Do you believe that Dr. Pegden's approach in this case has compared Act 131 against all possible districtings in Pennsylvania?

A. No, I do not.

Q. Do you believe that his analysis has compared Act 131 to an independent random sample of possible districtings in Pennsylvania?

A. No; and he doesn't think so, either.

Q. Okay. I'd like to turn for a moment with you to Dr. -- the approach Dr. Pegden takes to measuring partisan bias.

Dr. Cho, how does Dr. Pegden measure partisan bias in his report?

A. He uses the median/mean difference.

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Q. Okay. And what is -- what is the median/mean difference?

A. You basically compare the -- the mean vote to the median vote and check the difference. And if it's not the same, then there's a skew toward one party or the other.

Q. Okay. Is that the only way that one can measure partisan bias that may result from districting?

A. There's lots of ways to measure partisan bias. This is something I -- I've written on. There's no accepted way to measure partisan bias, in part, I think, because partisan bias is a multifaceted concept. Sometimes it's about -- you know, people talk about partisan symmetry. Sometimes people talk about competitiveness. Those -- those are different things. You can be competitive and not -- not have symmetry. You can be symmetric and not be competitive.

So there's lots of different facets of partisan bias. There isn't one measure that would measure everything. Nor are -- nor do we understand one measure to -- to be able to capture more than one facet.

So median/mean difference

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does something. It measures something. It doesn't measure everything. It's not the only way to measure it.

Dr. Chen chose to count the number of districts that -- that lean Republican versus lean Democrat. He also used median/mean. But there are lots of choices here.

Q. Okay. And why, in your view, was Dr. Pegden's choice of the median/mean difference significant to you?

A. He -- he talks about this in his paper that he published, and it's basically a mathematical choice. He needs a measure -- and he talks about this in his paper -- he needs a measure that will give you a different value, even if you only switch one VTD.

So, for instance, Dr. Chen's measure where you're counting how many seats are Republican and how many seats are Democratic -- if Dr. Pegden used that measure, most of his maps would give you nothing, right? It's hard to actually switch over a seat, especially if you're just switching one VTD. So that measure doesn't really work for him. Because if he had used that measure, then he would say, I traversed this trillion maps; oh, there -- you know,

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nothing there.

But with median/mean difference, even if you switch one VTD, you actually get a different number. I would call that mathematically different, but not substantively different. But it allows his algorithm to work, and part of it is he needs his algorithm to output a -- a -- a number. And for that, he needs something that has this fine-grained difference, even if that difference doesn't actually mean anything substantively.

Q. And, in your view, is that similar concern that -- is a similar concern of -- that you've raised about mathematical convenience or choice, to make a model work -- is that also a concern you have with respect to equal population -- his treatment of the equal population constraint?

A. Yeah, I think in my report, I said, you know, mathematical rigor must meet the rigor of the law, which basically means -- you know, you have mathematical rigor, but there's -- if you're applying it in this legal context, you need to have, you know, the rigor of the law basically, you need -- you know, you can't just make choices based on mathematical decisions or algorithmic decisions. You have to make the mathematical and algorithmic decisions fit the

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law.

Q. Dr. Cho, do you -- do you believe that it's -- it's -- is it fair to consider -- you've talked about swapping of VTDs, I guess just as an initial thing.

Can you define a VTD?

A. Yeah. It's a voter tabulation district, and it's -- it's the level at which we collect voting data. It's an administrative boundary.

Q. It's like a precinct, essentially?

A. Yeah.

Q. Okay. And do you think that it's a -- in your own research, do you draw -- do you attempt to draw samples of possible maps?

A. Yes.

Q. Okay. And do you draw -- when you're drawing samples with your -- on your supercomputer with your approaches, do you draw maps that are, you know -- as you pointed out with Dr. Pegden's approach, you know, very similar to a prior map, with -- with minor differences?

A. My approach is completely different. We don't -- we don't use this VTD swap much, almost never. If we swap around the edges, we often swap a

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number of VTDs. We don't usually swap one. That would be unusual.

We have other operators within the algorithm that that -- my algorithm which makes big jumps, basically from, you know, one map to another -- another good map, which would be a large jump. There are lots of things that have changed between these maps. And we've spent a lot of time thinking about how you -- how you do that.

The easy way to do it is to just move around a map by swapping VTDs on the boundary because that preserves contiguity. There are other ways to do it. And I -- I've written on that, how you do this in other ways, how you preserve these geographic constraints.

This is -- it's a superinteresting and not -- nontrivial problem.

Q. Okay. And based on -- on your own research and analysis, do you believe that it's fair to measure Act 131 against a large collection of maps that are nearly equivalent, as in Dr. Pegden's approach?

A. No, I do not. I think all those maps that he created, for instance, that just have this one swap of the VTD -- I don't see the point of a

1235

comparison to maps like that, even if they're -- even if they're different. It's -- it's essentially the same map.

Q. Dr. Cho, is there -- to your knowledge, is there any way to -- to measure -- to determine if Dr. Pegden's approach is comparing Act 131 against a representative sample of all, you know, legal possible, you know, redistricting maps?

A. No, it is not.

Q. Okay. And in the end, Dr. Cho, do you believe that Dr. Pegden has shown that Act 131 -- you know, with his approach, has shown that Act 131 has more partisan bias than, you know, over 99.99 percent of possible districtings in Pennsylvania?

A. He's done a comparison, and I think his -- his conclusions are overbroad for what he's done.

MR. LEWIS: Your Honor, at this time, we would tender the witness.

THE COURT: Cross-examination.

MR. LEWIS: Wait. Before I do, I forgot -- I have to move -- almost forgot. Can I -- I need to move in -- I need to move for the admission of her -- of her report, which is -- 10 or 11 -- so we would move for

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the admission of Legislative Respondents' 11.

I would add that -- that we have -- I have discussed with counsel redactions from that report around the Figure 2.

THE COURT: The discussion is great.

Do we have agreement about redactions?

MR. JACOBSON: I believe so, Your Honor. If we could just over the lunch break go back and confirm that we're not missing anything.

MR. LEWIS: Yes, Your Honor, we would -- I think I agree with that. We shared some possible redactions, and I think if there's any -- you know, we will work with counsel, Your Honor, to make sure that any remaining issues are resolved.

THE COURT: Okay. So we're going to adjourn -- or recess for lunch. When we come back, you will move your exhibits and we'll begin cross-examination.

Okay?

We'll take a break until, say, 1:30.

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MR. LEWIS: Thank you, Your Honor.

THE CLERK: The Court is now in recess.

(Whereupon, at 12:38 p.m., a luncheon recess was taken.)

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AFTERNOON SESSION

(1:45 p.m.)

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WENDY TAM CHO, PH.D.

was called for continued examination and, after having been previously duly sworn, was examined and testified further as follows:

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THE CLERK: All rise. The Commonwealth Court is back in session.

THE COURT: Please be seated, everyone.

Okay. Legislative Respondents were going to offer some exhibits, I believe.

MR. LEWIS: Yes, Your Honor. We -- we move to admit Legislative Respondents' Exhibit 11, which is the expert report of Dr. Cho. We note that we have reached agreement with counsel regarding the redaction of portions of that report that address Figure 2 and the simulation issue we had this morning.

And we will submit to the Court prior to the close of trial a redacted report to be inserted into the exhibit

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binder.
We would also move the admission --
THE COURT: Well, let's do one at a time.
MR. LEWIS: Excuse me. Yes.
THE COURT: Do we have an objection to the redacted Legislative Respondents' Exhibit 11?
MR. JACOBSON: No, Your Honor.
THE COURT: Legislative Respondents' Exhibit 11, as redacted by agreement of the parties, will be admitted without objection.
- - -
(Whereupon, Legislative Respondents' Exhibit Number 11 was admitted into evidence.)
- - -
MR. LEWIS: Your Honor, we would further move the admission of Legislative Respondents' Exhibit 12, which was the breakout of the figures and tables utilized in Dr. Cho's report.
As with Legislative Respondents' Exhibit 11, that Figure 2 that was the subject of discussion this morning was

1240

included, and we would proffer that we will redact that -- we will remove that page from 12 prior to the close of trial.
THE COURT: Any objection to Legislative Respondents' 12, as redacted by agreement of the parties, having that admitted into the record?
MR. JACOBSON: No, Your Honor.
THE COURT: And, Counsel, I'll ask that you tomorrow -- that by tomorrow, if not today, the substitution be made in the exhibit binders so we don't lose sight of that getting done correctly.
MR. LEWIS: Your Honor, that is a priority of ours. I would add that we're also going to have a discussion this evening with counsel because we were talking about striking portions of the testimony, and so once we have the daily transcript, we're going to be working on that as well.
THE COURT: Excellent.
MR. LEWIS: So that's top of mind, Your Honor.
THE COURT: Okay. Good.
Anything else?

1241

MR. LEWIS: Not -- I think we already got the -- we already got the CV in, I believe.
THE COURT: Which is what?
MR. LEWIS: Ten.
THE COURT: Ten has been admitted without objection.
MR. LEWIS: Great. That was all we had, Your Honor.
THE COURT: Okay. Cross-examination.
MR. GERSCH: Thank you, Your Honor.
THE COURT: Before we do cross-examination, Mr. Gersch --
MR. GERSCH: Sir?
THE COURT: Legislative Respondents have one more expert to testify, correct?
MR. TUCKER: Correct, Your Honor.
THE COURT: That's Dr. --
MR. TUCKER: Dr. Nolan McCarty.
THE COURT: Is Dr. McCarty in any way going to touch Dr. Pegden's testimony?
MR. TUCKER: Just thinking; but, no, I do not believe so, Your Honor.
THE COURT: Would you be willing to

1242

bet your case on that?
MR. TUCKER: Yes, Your Honor.
THE COURT: Okay.
So, Mr. Gersch, I'm going to ask, if I give you some time today, is there any -- I'm assuming you're going to call Dr. Pegden in rebuttal?
MR. GERSCH: Yes, sir.
THE COURT: Okay. Since Dr. Pegden is here, I'm wondering whether -- if we finish with this witness, Dr. Cho, whether -- if I give you some time, whether we could do the rebuttal with regard to Dr. Pegden today.
MR. GERSCH: Can I consult with my co-counsel?
THE COURT: Please.
MR. PALNICK: Are we off the record?
THE COURT: No, but we can be.
Off the record.
- - -
(Whereupon, a discussion was held off the record.)
- - -
MR. GERSCH: Yes, Your Honor, with

1243

respect to Dr. Pegden, if we have some time to prepare him, we would try and get him on today --

THE COURT: Okay.

MR. GERSCH: -- absolutely --

THE COURT: Let's see --

MR. GERSCH: -- and -- but it may be that we would have another rebuttal witness with respect to Dr. McCarty.

THE COURT: I understand that. I'm just trying to -- I think you understand what I'm trying to do.

MR. GERSCH: Absolutely.

THE COURT: So let's see if we can do that.

And let's now go forward with the cross-examination of Dr. Cho.

- - -

CROSS-EXAMINATION

- - -

BY MR. GERSCH:

Q. Good afternoon, Dr. Cho.

You testified on direct that Dr. Chen did not describe his algorithm in enough detail, correct?

1244

A. Did not describe his algorithm in enough detail in his report; that's what I said.

Q. That he did not?

A. In his report.

Q. Certainly.

He did disclose his code?

A. So I guess we can describe this.

He -- when I got his report, there was no code. You guys conferred -- you know, "you guys" -- and you came back, I think, a day or two later -- I don't remember -- with a confidentiality agreement that said I could have his code and his output if I signed the confidentiality agreement.

Counsel presented the confidentiality agreement to me, and I -- I looked at it, and I -- I refused it. And the reason I refused it is because the terms of the confidentiality agreement were such that if I were to take the code and look at it, that I would only be able to look at it for this case; I would have to return it; I would never, ever be able to discuss it again, not just in relation to this case, but in relation to anything: my academic work, anything.

And I explained that the reason I was not willing to sign that is because this is an area

1245

of research for me. Sometimes I write about what other people have done, for instance, Dr. Chen, and I say, Dr. Chen has done this and blah -- and the way the confidentiality agreement was written, it would have precluded me from doing that. And my primary job is as an academic researcher.

I don't really -- I don't want to say I don't care about this case. But I would have been happy to say I'm not going to discuss it outside this case or -- or with some less restrictive confidentiality agreement. I'm not a professional expert witness. I don't do this all the time.

I do this. I'm doing this; I want it to be separate from my -- from my work. And it was not going to be under -- under those conditions, and that's why I refused it.

Q. Understood, Dr. Cho.

But, in any case, it was offered to you and you chose not to take it?

A. This is correct.

Q. And the confidentiality agreement that you reference, that was wanted by defense counsel for their experts -- you understood -- by the Legislative Respondents' counsel for their experts.

You understood that, too, right?

1246

A. Yep.

Q. All right.

All right. So it was offered; Dr. McCarty got the code; Dr. Gimpel got the code.

You understand that, right?

A. I don't know what they did with it. I know I refused it --

Q. All right.

A. -- and I have not seen it.

Q. And, Doctor, you referred to Dr. Chen's academic work and -- in your testimony, you discuss the way he described his algorithm and his academic work.

Do you recall that testimony?

A. Yes.

Q. And in his academic work, on at least two occasions, Dr. Chen has disclosed his code; is that right?

A. In -- for his Quarterly Journal of Political Science article, he -- he has some code up. I've looked at that code.

For his other article, he posted something he calls "code." It is actually a binary executable. It is not code per se. I mean, the difference is, like, for instance, if I asked you for

1247

your -- let's say you wrote Microsoft Excel, and I said, Can I see your code? and you -- you give me a binary executable that when I click on it, it runs Microsoft Excel. Like, that's not what I asked for. That's what Dr. Chen produced on his Web page for the other article.

Q. I'm not sure I understand your reference to "that's not what I asked for."

He produced something that can be run?

A. One of them is a binary executable. The other one is source code. They're completely different things.

Q. My question is, They can be run? They can be run on a computer, yes?

A. They can be run. One of them needs to be compiled before it can be run. The other one actually needs to be ported to the correct system. And then there's some other stuff that needs to be done, and then it can be run.

Q. All right. And you have -- you haven't run his code for his academic work; is that correct?

A. I have read his source code.

The other one -- honestly, it's not like Microsoft Excel, where you just click on it and it runs. I'd have to know what the format of the

1248

input data would be. I'd have to know all sorts of things that would be in the code.

None of that is provided. It's just a clicking thing; you click on it, it doesn't run.

Q. My question was different.

You haven't run the codes that he disclosed; is that correct?

A. I have not.

Q. Thank you.

All right. Let's turn to the subject of incumbents.

You say that the -- that you infer that the legislature intended to protect incumbents in the 2011 Map; is that right?

A. That's correct.

Q. The 2011 Plan protected Republican incumbents; is that right?

A. It protect both Republicans and Democrats.

Q. Well, it protected all Republicans and some Democrats; isn't that right?

A. It went from 19 seats to 18 seats. Two of them obviously have to be paired in that instance. It's not really a pairing, since they lost a seat. One of them has to go. Somebody has to go.

1249

Q. My question was a little different.

The plan protected all Republicans; it did not protect all Democrats; isn't that right?

A. Two Democrats were put into the same district. I think there's -- there's a -- there's an argument there that -- that somebody had to be paired with somebody.

Q. All right.

So two Democrats are paired in the same district. They were paired in the 12th; isn't that right, the new 12th District?

A. I believe that's the one.

MR. GERSCH: Can we put up Joint Exhibit 17?

BY MR. GERSCH:

Q. Do you see that in front of you?

A. I do.

Q. And it's -- it should be both on the big screen and on your screen.

A. Yeah, I see it.

Q. All right. That's the 12th, isn't it?

A. Honestly, I don't connect them to numbers. I couldn't tell you if it was.

THE COURT: This is a stipulated exhibit, Dr. Cho, and at the top of the

1250

exhibit, you will see it says the 12th Congressional District.

THE WITNESS: Okay. I can agree that at the top, it says the 12th Congressional District.

BY MR. GERSCH:

Q. All right. But you're not familiar enough with the numbers to be able to match them up?

A. No, I'm not, except for the Seventh. I can identify the Seventh.

Q. All right. And you do know -- regardless of -- of whether you know which number goes with it, do you understand that it's about 120 miles from one end of the 12th to the other?

A. I'm also not that familiar with it that I could tell you it's 120 miles.

Q. All right. Well, if I tell you that and you look at the shape, you're not contending that this is some accident, that this was some random doing by the legislature that ended up with this district that paired the two Democrats together, are you?

A. Again, I'm not privy to secrets about who they picked and why they picked them.

MR. LEWIS: Objection.

1251

BY MR. GERSCH:

Q. Have you done -- well, withdrawn.

You've done no work to determine whether the pairing of the Democrats was done either by accident or for some nonpartisan reason?

A. I have not analyzed that question.

Q. All right. So let's assume that the -- what you called "the incumbency protection" that the legislature accomplished was, in fact, a partisan incumbency protection.

Would you say that's a legitimate legislative goal?

A. So I didn't say it was a -- what did you say? A partisan protection?

If you protect both parties, is that a partisan -- that's a bipartisan.

Q. Dr. Cho, I want you to assume that the 12th was drawn for partisan purposes, as blatantly partisan purposes as you can possibly imagine. I want you to assume that.

My question to you is, If you assume that what the legislature was doing was a partisan protection of incumbents, do you say that's a legitimate legislative goal?

A. It is my understanding that incumbency

1252

protection is a traditional districting principle, and the source of that being a traditional districting principle, in my opinion, is not so that the -- the legislature can go crazy with partisanship.

My understanding of it as a traditional districting principle is so that for -- for voters, it is something that -- it's the same thing like preservation of district cores: you don't change things so much for voters that they're confused, they don't know what's going on. That hurts the process.

That -- if people use partisanship excessively, that's a different -- that's a different question.

Q. My question was a little different.

My question is, If the -- if the incumbency protection is done for partisan purposes, do you say that's a legitimate legislative goal?

A. Again, it's -- it's -- these things always involve partisanship, so it's a matter of, you know -- what is -- what is -- how do you know if it's -- what the partisan goal is? Is it a bad partisan goal? Is it a good partisan goal?

There are good partisan goals, right?

This is why the Court allows

1253

partisanship to be used. They don't say you cannot use partisanship when you draw. If you don't use partisanship at all, you get -- you get crazy districts, right? If you know where the partisans are, you're not going to get anything near proportional representation, for instance.

Q. Dr. Cho, with all due respect, I'm asking a different question.

I'm simply asking if the -- if the redistricting that was done for partisan purposes, the most blatant partisan purposes you can imagine -- imagine they sat there for hours and said, How can we build a 12th District so as to ensure that the two people who are paired are Democrats and all the Republican incumbents are protected, and that we want to do that because we want to get more Republican Congressmen, and we want fewer Democratic Congressmen, and further imagine that they said, You know, it's going to be tough to do this, because this district makes no sense from a compactness standpoint; it makes no sense in terms of preserving communities of interest; it makes no sense whatsoever, but we're going to do it anyway because we want the partisan goodies.

Do you say that's a legitimate goal?

1254

A. That would be, I think, for the Court to determine, excessive partisanship, not for me to say.

Q. I'm sorry. You say you can't say?

A. That would be a legal decision, right?

Q. It might be. I'm just asking what you think.

A. I don't have a legal opinion on that.

Q. Okay. You don't have a legal opinion.

You gave a legal opinion in your report and in your direct about Dr. Chen should have used more VRA-compliant maps, didn't you?

A. He didn't even try to create VRA-compliant maps.

Q. I didn't ask -- you were giving a legal opinion then?

A. No. I'm saying he didn't even try to -- he didn't -- he didn't even try to create VRA-compliant maps.

Q. All right. We'll come back to that.

Put aside the question of whether it's a legal opinion or not.

If you're simulating maps to figure out whether -- withdrawn.

You have a measure that you use for

1255

analyzing gerrymanders, correct?
A. I have many measures.
Q. All right, fine. Any one of them.
Someone sits down and asks you to do it, you're not going to incorporate into your simulated maps, are you, districts that have been blatantly gerrymandered for partisan purposes, are you?
A. If somebody asked me to generate maps that way, I can generate maps that way. I'm not saying -- I'm not making a legal opinion, but it can be done. I can do that.
Q. Okay. So -- so if we turn it around, then, you're not in a position to say that if -- if -- if this was a partisan -- if the incumbency protection here was a partisan -- blatantly partisanship incumbency protection, then it might well be okay not to include incumbency protection in the simulation of the maps; isn't that right?
A. Again, this is -- this is a legal decision. When I draw maps, I can incorporate partisanship. The point at which my incorporation of partisanship is excessive in a legal sense, I don't make that judgment.
Q. That's not my question.

1256

My question is --
THE COURT: Honestly, I don't understand your question --
MR. GERSCH: Certainly.
THE COURT: -- I think what she's saying is -- I think what her position is is where the line of allowed partisanship and excessive partisanship occurs is a legal question. And -- and I think she's actually right. I think you know she's actually right on that point.
MR. GERSCH: With all due respect, Your Honor, what the witness has testified to is that Dr. Chen didn't do a good job of simulating his maps because he was supposed to incorporate incumbency protection. And we're not going to solve with this witness whether the 12th is a partisan --
THE COURT: Just on that, respectfully interrupting, I didn't hear her testify to that.
MR. GERSCH: She testified that she can't tell.
THE COURT: No. I heard her testify that -- if I understand what her

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testimony was on this subject, was she doesn't believe Dr. Chen's simulations were good simulations because he didn't account for partisanship. I think --
MR. GERSCH: And incumbency protection.
THE COURT: -- account for incumbency protection, which includes a component of partisanship. That was what I understood her testimony was.
BY MR. GERSCH:
Q. Is that your testimony?
A. It was.
Q. I want you to assume -- well, withdrawn.
You do cite cases in your report?
A. I do.
Q. You cite cases both with respect to your opinions about Dr. Chen and with respect to your decision about Dr. Pegden?
A. I did.
Q. Okay. You cite Supreme Court cases about incumbency protection?
A. I did.
Q. All right. One case I didn't see you

1258

cite was the Pennsylvania Supreme Court's decision in Erfer versus Commonwealth?
A. That's true.
Q. You understand in that decision -- in that case, the Pennsylvania Supreme Court said that the 2000 legislative map was deliberately drawn to give advantage to the Republican party?
A. I didn't read that case.
Q. All right. Assume they said that.
You don't think it's a good idea to build a nonpartisan map on a map that was gerrymandered for partisanship purposes, do you?
A. So was -- was that map declared a partisan gerrymander?
Q. It was exactly what I said. They found that it was deliberately drawn to grant advantage to the Republican party.
MR. LEWIS: I'm going to object. I think that's mischaracterizing the decision.
THE COURT: I'm going to sustain the objection.
She asked you for clarification of your question, Mr. Gersch. If you don't want to clarify it -- if you want to give her a hypothetical of a court ruling,

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that -- but I think she was asking you a fairly legitimate question in response to your question.

MR. GERSCH: I thought I asked her to assume it, but --

THE COURT: Well, you were saying specifically the Erfer case. If you're going to ask about a specific case, you need to give the witness all of the rulings from that case.

MR. GERSCH: I understand. And I'll -- I will separate out --

BY MR. GERSCH:

Q. Forget about the Erfer case. Just assume that the Pennsylvania Supreme Court has held -- or said that -- that the 2000 Map was deliberately drawn to advantage the Republican party.

If it was arguably a gerrymander -- the 2000 Map was arguably a gerrymander, you don't think it's a good idea to build simulated maps based on an arguably gerrymandered map, do you?

A. I guess I'd ask the same question. Is it a partisan gerrymander -- or is it arguably a partisan gerrymander?

Q. Use the word "arguably."

1260

A. If we're using the word "arguably" partisan gerrymander, then I -- I don't see the basis to exclude it. Somebody's argued it, somebody else has not argued it, I think.

Q. Isn't it your position that philosophically, incumbency protection does not make sense if the current map is arguably a gerrymander?

A. Incumbency protection has a partisan component. Part of that partisan component is good, part of it is bad.

It is not my assessment to say this part is good, this part is bad, that has -- that piece of it is part of this idea of using partisanship excessively. If you use it excessively, my understanding is there's some line at which you cross where you're doing the bad stuff. If you don't use it excessively, then you can just be doing the good stuff.

I don't -- I don't draw this line, and you're not helping me draw this line.

Q. My question was a little different.

My question was, Isn't it your position that philosophically, incumbency protection doesn't make sense if the current map is arguably a gerrymander?

1261

A. So, again, someone's argued yes and someone has argued no, right?

MR. LEWIS: Objection.

THE WITNESS: The way you phrased the question implies that it's -- it's bad and someone has argued that in such a way that we know it's bad.

BY MR. GERSCH:

Q. It's my language that's giving you trouble, is that right, the way I'm phrasing it?

A. Yes. Yes.

Q. All right. Let's try one more.

It's also your position that if the current map is arguably a gerrymander, it really doesn't make sense to preserve it?

A. I'm really having trouble seeing the difference between that question and the last question and the one before it.

Q. They were similar. I -- I don't dispute that.

Dr. Cho, isn't this exactly what you said at Tufts University in August at the Metric Geometry and Gerrymandering Group sessions?

A. Remind me.

MR. GERSCH: Can we put up a video

1262

of the session? The witness has asked to be refreshed.

I'll represent that I took -- well, I didn't -- we took this off of YouTube --

THE WITNESS: I'm aware this is on YouTube.

(Video shown.)

BY MR. GERSCH:

Q. Dr. Cho, isn't it your position that philosophically, incumbency protection does not make sense if the current map is arguably gerrymandered?

A. No. What I was saying there is exactly what I'm saying here. It --

Q. Dr. Cho, didn't you say there, philosophically, incumbency protection makes sense -- doesn't make sense if the current map is arguably a gerrymander?

A. I see that you're using my words, and now I know why you keep saying that, but there is context to what I was saying there --

Q. Dr. Cho, I don't mind if you add the context. I'd like you to answer my question --

THE COURT: Counsel, she did answer the question. Let her explain the answer.

MR. GERSCH: I don't believe she

1263

said yes, that she said those words.
THE COURT: We just heard the words. We know she said them. She now wants to explain them.
Dr. Cho, please explain.
THE WITNESS: So what I'm saying there -- so I started off by saying they're the traditional district principles that the Court really likes, they talk about all the time, compactness, contiguity, you know, preserving -- preserving cities. And then there are these other two that in my opinion and as I express in the video, they're kind of a little below if you're going to rank them -- as I said, if you're going to rank them, the Court likes these a little bit less.
And one of the reasons I say that is because in -- in the Supreme Court cases, they -- they always mention compactness. Right? They mention preserving cities all the time.
Sometimes they mention incumbency protection, and sometimes they mention preserving district cores, but they are

1264

mentioned less often than the other ones. And the reason they are mentioned less often is because sometimes you can use them in -- in -- in a bad way, as it were; sometimes you can use them in a good way.
And the Supreme Court likes it if you can use it in a good way. They don't like it if you're -- if you're using that as -- as -- in a bad way, which is, again, this -- going back to this notion of excessive partisanship.
I think it's the same thing I've been saying. I think, here, I can clarify for you what I was saying. It's -- I haven't changed my mind since I said that. And the reference there was to MCMC techniques.
MR. GERSCH: Your Honor, I think I can move this along with one clarification from you, the Court, or the court reporter.
Does the court reporter take down the -- what was said on the video?
THE COURT REPORTER: No. I just put a video is viewed.

1265

BY MR. GERSCH:
Q. Then I have to ask you, Dr. Cho, didn't you say on the video that philosophically, incumbency protection doesn't make sense if the current map's arguably a gerrymander?
A. Yeah.
And I'm explaining to you that philosophically, what's bad about that is that you can use it in a bad way.
Q. Yeah. And I just need to do this for the record, you understand, Dr. Cho --
A. Yes.
Q. -- because the video doesn't get picked up.
And didn't you also say that if the current map is arguably a gerrymander, it doesn't really make sense to preserve it?
A. I said that with respect to that North Carolina district that has the 12th; that one was ruled a gerrymander by the court. And that's why I would put that map up and made that reference to that map.
Q. Okay. But you said it?
A. Sure. It -- it can be taken that way, or you can -- you can take it with my explained

1266

context around it.
Q. We'll move on.
Didn't you also say in your article, Toward a Talismanic Redistricting Tool --
MR. GERSCH: Why don't we put this up so that the witness doesn't have to just listen to me say it? We'll shorten it.
BY MR. GERSCH:
Q. The Talismanic Redistricting -- Talismanic Redistricting Tool is one of your papers?
A. Yes, it is.
Q. All right.
MR. GERSCH: Let's put that up. It's Exhibit 252. This is a new exhibit.
THE COURT: So we're going from 200 to 252?
MR. GERSCH: Yes, Your Honor. We didn't know where we would be when we started this and . . .
BY MR. GERSCH:
Q. Dr. Cho, do you want to read off the screen, or would you like it in hard copy?
A. I can read off the screen if you make it bigger.
MR. GERSCH: Your Honor, would you

1267

like it in hard copy?
THE COURT: Yeah, I'd love a copy.
MR. LEWIS: Your Honor, Legislative Respondents would request a copy of the article. We would also request that the witness be provided with the full article.
MR. LEVINE: What else did you say at the end?
MR. GERSCH: We'll be passing out copies.
May I approach, Your Honor?
THE COURT: You may.
THE WITNESS: Thank you.
THE COURT: Dr. Cho, take whatever time you need to review it, and let us know when you're done. And counsel will start questioning you about it.
- - -
(Petitioners' Exhibit Number 252, marked for identification, as of this date.)
- - -
MR. GERSCH: For the convenience of the witness, we're going to look at

1268

Page 352.
THE WITNESS: Okay.
BY MR. GERSCH:
Q. Just let me know when you're ready.
A. I'm ready.
Q. All right. In your -- in your paper, Exhibit 352 -- and I'll just read it -- didn't you say, In the incumbent or bipartisanship gerrymanders that deny voters the chance to use their votes to effect change in the legislative representation, one might argue that jurisdictions that use political data in redistricting are conditioning state action (i.e. district design) on the content of past speech (e.g. previous vote history or voter registration) in order to create safe incumbent seats or safe Democratic- or Republican-held seats?
A. Yes, I said that.
Q. All right. And you didn't say that as an endorsement of incumbency protection, did you?
A. No.
Q. The suggestion that you're making there is incumbency protection, in certain circumstances, would violate the First Amendment?
A. I think I say there at the beginning of the sentence that there is a bipartisan gerrymander,

1269

which, again, would imply an excessive use of partisanship, which, even there, is arguable, right, because the Supreme Court hasn't issued a majority opinion on partisan gerrymanders -- bipartisan gerrymanders, partisan gerrymanders. There's -- there's no legal decision on this.
So this -- when I use that sentence in that way, it is assuming that we actually know what that is. It's -- that it is measurable, has been measured -- has -- this is unquestionably a -- a partisan gerrymander.
Q. Understood.
So if it's unquestionably a partisan gerrymander, then we should be thinking that this is a First Amendment violation, correct?
MR. LEWIS: Objection: calls for a legal conclusion.
MR. GERSCH: I'm asking for her opinion. She's written about it.
THE WITNESS: Yeah. You know --
THE COURT: Hold on for a second.
She wasn't qualified as an expert on the law. Now, if -- but I'll let you rephrase your question and keep it confined to the opinion that she expressed in this

1270

article, which is certainly a fair ground for cross-examination.
But as to an ultimate question of law --
MR. GERSCH: Certainly. Your Honor, I'll stipulate we don't want an ultimate question of law.
THE COURT: Then phrase your question so you're not asking that.
BY MR. GERSCH:
Q. The opinion that you're expressing in this article, as I understand your clarification on testimony, is that if it is unquestionably a partisan gerrymander, that we should be thinking that this violates the First Amendment.
Isn't that your opinion?
A. It's possible. It's -- it's -- it's an idea. Whether that is actually true would be for the Court to say. I'm not aware that I'm so influential that when I say something, the Supreme Court takes notice and makes it -- makes the law.
Q. I'm just asking whether that's the opinion in your article, that's the idea you want to convey --
A. It's possible -- it's possible you can

1271

have a First Amendment violation. This is a route to getting a partisan gerrymander standard, somehow.

Q. All right. Just to follow up on the notion of building upon a gerrymander district --

MR. GERSCH: And I'm not -- I want to make clear we understand the witness is not testifying that the 2001 Plan was a gerrymander district.

BY MR. GERSCH:

Q. Do you understand that in 2000 -- in the 2001 Plan, six Democratic incumbents were paired together?

A. I don't understand that -- I mean I didn't know that.

Q. All right. Do you know -- you know who Congressman Murtha was?

A. I'm actually not that familiar with that plan.

Q. Okay. So if Congressman Murtha was paired with later Congressman Mascara, you wouldn't know about that?

A. No.

Q. If Congressman Borski was paired with Joseph Hoeffel, you wouldn't know about that?

A. No.

1272

Q. And lastly, if Congressman Coyne was paired with now Congressman Mike Doyle, you wouldn't know about that either?

A. No.

Q. I think you said on direct that one reason to -- incumbency is protected -- and -- correct me if I got the words right -- wrong. I tried to write it down -- was the notion that you've got to make the legislators or the stakeholders happy enough they'll pass the map?

A. I didn't say you have to. I said that this is -- that -- that's part of the traditional districting principle. That's why it's one of the traditional districting principles.

Q. Because you need to get the votes --

A. No, no -- okay. I'm sorry.

No. I said -- I said that one of the reasons that the -- that the legislature does it is -- is -- that could be one of the reasons. I did say that.

Q. The reason being that they need to get the votes in order to pass it, and so you've got to satisfy them --

THE COURT: Hold on.

Cross-examination can get a little back-and-forth, but you have to try not to interrupt counsel, and he has to try not to interrupt you, and vice versa. I think you will both be able to do that.

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BY MR. GERSCH:

Q. I'm just trying to make sure that we have your testimony accurately on this.

I understood you to be saying that one of the reasons that legislators protect incumbency is because when they make the map, you're going to have to satisfy them or enough of them to get their votes.

Is that about right?

A. Yes. I think that's -- that's a constraint. Whenever you draw redistricting maps, you have to worry about whether or not it's going to get -- you have the votes.

Q. Okay. And just because the legislator thinks -- just because you have to make the legislators happy enough that they'll vote for -- or willing enough to vote for it -- I think "happy" may have been your term -- that -- that doesn't independently make this a legitimate goal, does it?

A. I'm not saying whether that makes it a legitimate goal or not. I'm merely saying that this is a constraint upon the process. The fact that the

1274

map has been passed means it had enough votes to pass.

Sometimes you need to -- I don't think the word is "compromise," but sometimes you need to work with different people to make sure it's -- it's passed.

Q. Sure, but -- but I take it -- you wouldn't quarrel with the proposition that sometimes what the legislators want is -- is improper?

Let me give you an example.

If the legislators want to have prayer in school, that would be unconstitutional, right?

A. There are unconstitutional things that people want, yes.

Q. All right. Let's move on to the VRA.

You said that compliance with the VRA is required by law; is that right?

A. Yes.

Q. In your report, you said that 741 of Dr. Chen's maps must be thrown out -- and, here, I'm quoting your report -- since these -- these plans do not consider the requirements of the Voting Rights Act, they are not legally compliant districting plans.

That's what you said, right?

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A. I -- it sounds like something I said --
Q. Do you have your report there?
A. -- I assume you're reading to me.
Q. Yes.
Do you have your report there?
A. I do.
Q. It's on Page 23.
A. Okay.
I'm there.
Q. All right. Did I get that right?
Since these plans do not consider the requirements of the Voting Rights Act, they are not legally compliant plans?
A. Yes.
Q. The point you were making is that Dr. Chen reported that 259 of the simulated plans contained a district with 56.8 percent or higher African-American voters -- voting-age population, and so you said that the other 741 should be thrown out; is that right?
A. So there's a little bit of a distinction there. I'm not saying --
THE COURT: Dr. Cho, you answer -- I did this yesterday. You weren't here -- answer the question, then you can explain

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it.
So if you want -- I think it was a yes-or-no question --
THE WITNESS: Okay.
THE COURT: -- it's yes or no, and then feel free.
THE WITNESS: Got it.
So, yes, I said that the 741 should be thrown out. That not does not mean that the 259 are necessarily compliant. At most, 259 are possibly compliant.
BY MR. GERSCH:
Q. And the reason you said that 741 should be thrown out is because Dr. Chen didn't say they had 56.8 percent or higher African-American voting-age population, and you correctly inferred that that meant the other 741 [verbatim] didn't?
A. Okay. I'm not saying that to be a VRA-compliant district, you have to have 56.8 percent. I'm not making a statement like that. I'm not making a legal judgment here about what is and what does not satisfy the Voting Rights Act.
It's possible one of these districts that he drew that doesn't have 56.8 black VAP, the Court would rule was not -- was or was not in

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compliance with the VRA. I don't know if they would.
In my opinion, since he didn't even try to comply with the VRA and that these maps don't even have a district that is like the district -- the VRA district that exists, then we should throw them out.
Q. The 741?
A. Yes.
Q. So we can have a concrete statement -- so if the district they created was 55.3 percent African-Americans, voting-age population, in Philadelphia, you would say it's got to be thrown out?
MR. LEWIS: Objection: mischaracterizes the witness's testimony.
THE COURT: Overruled.
THE WITNESS: So I'm saying -- first of all, I don't know what percentage that the other maps had as black VAP. I'm only given this one piece of information, that this number is at least as big as the District 2, which, in my opinion, implies that Dr. Chen thinks that these are the ones that would -- he would proffer as satisfying the VRA.
Whether they do or not, of course,

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is -- is a legal decision and needs to be, you know, discussed in that context. Here, I don't think there's -- there's a reason to -- I mean, we could go through every map and discuss whether or not it's a VRA-compliant map, but --
BY MR. GERSCH:
Q. Dr. Cho, isn't it right that there are 534 maps with over 50 percent African-American voting-age population among Dr. Chen's 1,000 simulations?
A. After I wrote this report -- I don't remember how many days after, but some number of days after, I was sent a new histogram of maps that were now, instead of 56.8, were 50 percent. I wasn't sent any narrative with it. I didn't know why it was being sent to me.
I got a new histogram. I don't actually even remember how many maps were 50 percent black VAP in the new histogram. I wasn't sure why they were sent to me.
But if that's what it showed, then that's what it showed.
Q. Sure. But you could have derived this from the backup if you were willing to look at it?

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A. From the what?
Q. From the backup information, the code and the backup information provided by Dr. Chen -- or offered by Dr. Chen and not taken by you.
A. I -- I guess, if I had the maps, I could have gone through all 1,000 of them and summarize that for myself. I could have summarized many things, I suppose.
Q. Wasn't it intuitive that you would end up -- even without controlling for a 56.8 percent district, wasn't it intuitive that you were likely to get a lot of 50 percent-plus African-American associate -- African-American voting-age population districts in the Philadelphia area?
A. I haven't drawn them myself. I assume that, you know, whatever we wanted to find as likely, there certainly are a lot there. But whether that would be compliant with the VRA, again, is a legal decision.
There's -- you know, you've got to go through the whole are they politically cohesive; is there racial bloc voting; do they this; do they that; is there -- you know, is it a Section 2 thing.
It's not a VRA case. We're looking at simulated maps. We make -- I said -- he said, not

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me -- he said this many are 56.8, which I infer that he thought these are the ones that satisfied VRA.
I mean, I don't know why he would present those as a separate thing if that wasn't the intention. It seemed to me that was the intention. I was just -- I was going with it.
Q. All right. But you didn't do any work to determine how many 50 percent-plus African-American voting-age population districts were created by the thousand maps?
A. I did not.
Q. All right. You also didn't do any work to determine whether any Voting Rights Act district was required?
A. Whether or not it was required?
Q. Right.
A. There -- there was one in the -- in the previous map. I assume that was one --
THE COURT: Dr. Cho, what previous map?
THE WITNESS: The current map.
THE COURT: The current map of Pennsylvania?
THE WITNESS: District 2.
THE COURT: Okay. So the map that

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we're litigating in this case?
THE WITNESS: Yeah.
THE COURT: Okay.
THE WITNESS: So -- I'm sorry. What was the question?
BY MR. GERSCH:
Q. I'll restate it -- or I'll -- I'll -- I'll approach this from a different path.
Let me pick up on your earlier testimony.
There are -- there's a legal test under Gingles, three-part test for when a VRA district is required, correct?
A. Correct.
Q. I've seen you cite that, right? You've cited that in your papers?
A. It's necessary but not sufficient, yes --
Q. Okay. And --
A. -- it can be necessary but not sufficient.
Q. -- in the three-part test, there are certain factual showings that must be made, right?
A. Yes.
Q. All right. The first is that the

1282

minority group must be able to demonstrate that it is sufficiently large and geographically compact to constitute a majority in a single-member district, right?
A. Yes.
Q. Okay. And you didn't do any work to determine whether that was the case in any -- in any of the Pennsylvania maps?
A. I did not.
Q. Pennsylvania districts, I should have said.
A. The simulated maps.
THE COURT: That -- that was my confusion, Counsel. We're going back and forth between the simulated maps and the --
MR. GERSCH: Certainly, certainly.
BY MR. GERSCH:
Q. I mean in the actual map.
You've not determined whether there's a district -- let's start with the actual district -- you haven't determined whether the first criteria of Gingles is met with respect to any district in the enacted map?
A. So in the current map, you're asking me is it my opinion that it's a Voting Rights Act

1283

district?

Q. No. I'm asking you -- you didn't do any work to determine whether the first Gingles factor is met?

A. That's correct.

Q. Okay. And the same certainly would be true for the enacted maps, right -- I'm sorry -- for the simulated maps?

A. That's correct.

Q. Let's go to the second Gingles factor, Minority group must be able to show that it is politically cohesive.

You didn't do any work to determine whether that was true for either the enacted plan or any of the simulated maps?

A. That's correct.

Q. And the third factor is, the Minority must be able to demonstrate that the white majority votes sufficiently as a bloc to enable it, usually to defeat the minority's preferred candidate.

You didn't do any work to see if that was true with respect to the enacted map or any of the simulated maps?

A. I did not. I'm purely going by the fact that Dr. Chen presented his maps, and then he

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said, These have this percentage of this minority, which I assume means it's a Voting Rights-compliant act. If it's not a Voting Rights-compliant act, it's still arguable that there needs to be one.

I think when we simulate maps -- when I simulate maps and when I've seen other people simulate maps, we generally go and look to see if there's a Voting Rights district, and if so, we don't just break it up. That becomes part of the simulation process. We think about that when we're doing the simulation.

Q. But you didn't look into that here, did you?

A. I don't, myself, decide that something is a Voting Rights Act or is not. I do decide whether it's likely to be one or not. And if it's likely to be one, which I usually can tell by the percentage of minority in the district, then I try to keep it.

Q. You didn't do that analysis here, is my point. You didn't do the three-factor Gingles test here?

A. I did not.

Q. Okay. And it's not at all intuitive, by the way, that the white voting population of

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Philadelphia votes in a bloc fashion to defeat minority candidates, is it?

A. Certainly that's something you have to do a lot of analysis on, and the Voting Rights Act cases are never simple.

Q. I'll move on.

Dr. Cho, you said you inferred from Dr. Chen's report -- Dr. Chen never says that the -- that there's a required Voting Rights Act in Pennsylvania -- district in Pennsylvania, correct?

A. I'd have to go back through it, but I think it was clearly implied.

Whether or not it was said -- I'll give -- I don't know if it was said or not. I'd have to go back and look.

Q. All right. The record will be as it is. I'm sure -- the record will reflect what he said.

I know the Court will be pleased with that approach.

All right. The bottom line is you're certainly not in a position to offer an opinion as to whether the three Gingles factors have been met?

A. No, I'm not of that opinion. And when we do simulations, we don't -- we don't make that

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opinion.

But we do make assumptions of whether or not we need to keep a certain minority, like -- I'll call, instead of VRA-compliant, minority -- majority-minority district.

Q. Well, it certainly wouldn't be right to say we've got to throw out those 741 maps because they're not compliant with the Voting Rights Act.

You can't make that statement, right?

A. I cannot make that statement. I cannot -- you know -- I will say yes, I can make no legal statements about what can be thrown out and what cannot be thrown out based on the VRA without having done that assessment.

But in this case, I think it's clear what everybody is thinking. I don't think Dr. Chen would say anything to the contrary. That's why he pulled out those maps. That's why he separated them. It's not like I separated them.

Q. You're not testifying as to Dr. Chen's intent now, are you? His mental state?

A. No, I'm not testifying as to his mental state. I'm testifying that he separated out those maps. He talked about the percentage of minorities in those maps. And so there is this clear

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implication that the reason he did that is because he didn't do anything for the Voting Rights Act when he did his simulations. But now he wants to say these -- these keep a certain percentage of minority intact in a district.

Q. Dr. Chen, isn't it true that --

A. I'm Dr. Cho.

Q. -- that he needed to throw out the 740 -- I'm sorry. My apologies.

Dr. Cho, didn't you say that Dr. Chen needed to throw out those 741 maps so that you could cast doubt on his report, even though you had no idea whether any VRA district was required?

A. I think that kind of analysis doesn't work with this simulation stuff. It -- he didn't try to comply with the VRA. You have to comply with the VRA to be a legally valid map.

I think it's pretty clear that this is why he pulled out 259 of his maps in a separate histogram giving statistics about what percentage of a minority were in those districts.

Q. Dr. Cho, my question wasn't that hard.

My question simply is, you had no idea whether any VRA district was required -- the reason you've said, Oh, Dr. Chen should have thrown out

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those 741 maps was to cast doubt on his methodology?

A. I'm not casting doubt on his methodology. I'm saying that that -- I -- I did cast doubt on his methodology, but that particular sentence is not about casting doubt on his methodology. That particular sentence is about something else.

But I did cast a lot of doubt on his methodology.

Q. Let's put up -- let's move on.

MR. GERSCH: Let's look at Figure 3 from Dr. Cho's report.

THE WITNESS: What page is that on?

BY MR. GERSCH:

Q. It's your report, Page 25.

A. Okay.

Q. So I understood your testimony -- and you can correct me if I've got this wrong -- that you said that there should be maps in that white space where you've got the blue circle, right?

A. I said that there are maps that satisfy those criteria that are not plotted.

Q. Okay. So just so the record's clear, you understand that what -- and the -- the -- the figure on the left side, that's your -- you took that

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from Dr. Chen's report, as you described, and you put the -- the blue circle and the green writing on it?

A. Yes.

Q. Okay. So you understood that when Dr. Chen made that figure, all he was doing was reporting his results, right?

A. Yes, that's his figure to report his results.

Q. And the reason there are no maps where the blue circle is is because the simulated maps that he generated -- there are no maps in that area?

A. Yeah. They were not easily accomplished, in his words.

Q. I'm just saying there were no maps -- he generated no maps.

That's the reason there's that white space, correct?

A. Yes, his are his easily accomplished maps. And those were not easily accomplished, whatever maps that could exist there.

Q. Dr. Chen -- Dr. Cho, one other thing I wanted to clarify. You said of Dr. Chen's two simulations that when you preserve the cities, the maps become more Republican.

Isn't it true that Dr. Chen constrained

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the choices so as to preserve the cities in each of his two simulations?

A. Yes.

Q. So your statement was incorrect?

A. Give me my statement again.

Q. You said, of Dr. Chen's two simulations, that when you preserve the cities, the maps become more Republican.

He preserved the cities in both sets of simulations.

A. Yes. So in -- in the Simulation Set 1, he preserved fewer cities. In Simulation Set 2, he -- wait. In Simulation Set 1, he preserved more cities. In Simulation Set 2, he preserved fewer cities.

That's what I said, and that's consistent with what I said before. And that is inconsistent with what you just said.

Q. Well, let's try it this way: He didn't impose a different city's constraint -- withdrawn.

Let me rephrase it this way: Dr. Chen didn't change his parameters for avoiding municipal splits from one simulation to the other, did he?

A. So you would say I didn't see the code, so I have no idea, but in one, he preserved more

1291

cities than in the other one, and then in the other one where he -- he added incumbency protection, the number of Republican-leaning seats went up.

Q. Is the answer to my question you don't know?

A. The answer to your question -- give me the question again.

Q. The question was -- the question was, In the two simulations that Dr. Chen ran, he did not change his constraint on city splits from one to the other?

A. In his description, he says he preserved cities for both.

Q. And you understand that he preserved them in exactly the same way in both; isn't that right?

A. I assume so, but --

Q. And when you say that in one simulation, there are fewer city splits than in the other, that's not something Dr. Chen did; that's what gets generated when he runs his simulation, right?

A. Yes.

Q. All right.

Okay. Let's move on to Dr. Pegden.

MR. GERSCH: And I don't know if the

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Court wants to take a break at some point. This would be a convenient point, but I can keep going.

THE COURT: I'm good. I don't know if the court reporter needs a break.

Let's take a 10-minute break.

THE CLERK: The Court is now in recess.

- - -

(Whereupon, a recess was taken from 2:43 p.m. to 3:03 p.m.)

- - -

THE CLERK: Ladies and gentlemen, the court is now in session.

THE COURT: Please be seated, everyone.

I apologize. My 10 minutes are getting a little bit longer every time we take 10 minutes. I'll try to get them back to Greenwich Mean Time.

Proceed.

MR. GERSCH: Thank you, Your Honor.

BY MR. GERSCH:

Q. All right. We've been talking about Dr. Chen. I want to move to Dr. Pegden, who you also

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addressed in your report.

Let's start by talking about the way Dr. Pegden's test works.

And I think we'll be on the same page as this.

From a mechanical standpoint, Dr. Pegden's test makes a sequence of small random changes to the actual map subject only to the limitation that the changes don't break his constraints; is that right?

A. That's -- this was a point of clarification I made in my report. I don't know if the -- each move of his trillion are valid maps, meaning they're a trillion maps, or if it's -- some of them break constraints, so it's a trillion moves but not a trillion maps.

Q. You would know this if you looked at his code, right?

A. If I looked at his code?

Q. Yes.

A. Yes.

Q. And his code is publicly available, correct?

A. This is -- this is correct.

Q. And it's been available for almost this

1294

entire calendar year?

A. So this is --

Q. Is that right?

A. -- I -- as I'm aware, it has been on the -- the Internet the whole time, yes. And so let me -- let me clarify this, because I -- I think I should have clarified this with Dr. Chen as well.

There's -- there's a difference between code and what you're trying to do, the algorithm, per se. So, for instance, I understand what Dr. Chen is trying to do regardless of whether I see his exact code or not because he's described it well enough and I know what the algorithm is intended to do, right?

So he has this -- he has this random element in it. It's essentially a Monte Carlo simulation. This is what he's attempting with this code.

I understand Monte Carlo simulations, so the -- what I'm trying to say is I use this analogy all the time, but it's -- it's a tool, the code, the method. It's a tool. And I understand tools. This is a claim of mine, is that I understand how tools work. I'm an expert in tools, as it were. And there's -- usually, when you have a tool, you have a task that you're trying to do.

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So I've used this example before, but let's say you're trying to drill holes into a wooden beam, right, so the proper thing to do there is to go get the right tool, which would be a drill. If you try to use a hammer, you're not going to get very good holes. And I know that because I'm a hammer expert, right, I've used hammers, I use hammers, and so I know if you're going to try and drill holes and you're going to use a hammer, you're probably not going to do a very good job, right?

And if somebody comes by and says to me, You haven't seen my exact hammer, meaning you haven't seen my code, then I'll say, Okay, sure, I haven't seen your exact hammer, but you did use a hammer, and a hammer has certain limitations.

I know that because I'm a hammer user, right, I -- I understand hammers.

With Dr. Pegden, it's the same type of thing. So if you want to berate me about not looking at his code, I felt like I could understand what he was doing without looking at his exact code. So this -- this point here about whether it was a trillion steps or a trillion maps, I could have borne into the code to figure that out, what he does when he hits a map that's not a valid map, or he could

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have said it in his report.

I didn't have very many days to work on this report. If you had given me the code, it would have taken me -- I don't know if you've ever read code, but code's hard to read. It takes a long time to read code, and I felt like I understood what he was doing well enough that I wouldn't have to do that.

The trillion maps versus the trillion steps is not, like, a make-or-break thing with Dr. Pegden's code. And neither was it, I felt, important for me to see Dr. Chen's code. All that was important for me to know was he's using a hammer. And I understand hammers, and I understand hammers can't do this.

So that -- that, I think -- I hope clarifies this whole distinction with, Did you see the code?

No, I didn't see the code.

Q. And, Dr. Cho, just to be clear, I didn't ask you any questions about any trillion steps, did I?

A. No. I -- I -- I brought that up.

Q. And I hate to say this, but now you're saying that you understood what Dr. Chen was doing.

1297

You testified on direct that he didn't describe his algorithm in enough detail; is that right?

A. Yeah, there's certain details that I pointed out in my report. I said he didn't give me the exact steps for when -- if you were going to break a city or break a county, which do you choose to break, the city or the county? Or do you use choose to break compactness, or do you choose to break whatever? But the point there is, he chooses, it's deterministic how he makes those steps, and it's a deterministic algorithm, not a random algorithm.

Q. Well, we'll see about that.

Let's go back to Dr. Pegden.

So my original question was -- which spurred this digression was, You understand that mechanically, the way Dr. Pegden's process works is that he makes a sequence of small random changes to the actual map subject only to the limitation that the changes don't break his constraints; is that right?

A. Yes, so he examines whether it has broken the constraints or not.

Q. I'm sorry. I didn't hear the answer.

THE COURT: She said, "Yes" -- she

1298

said, "Yes, so he examines whether it has broken the constraints or not."

BY MR. GERSCH:

Q. And the constraints are equal population within a 1 or 2 percent error, not splitting counties, and that the districts are produced -- that the districtings produced by his process are at least as compact as the actual map, right?

A. So, as I recall --

THE COURT: Dr. Cho, does it say that?

THE WITNESS: Does it say that he does that?

THE COURT: Yes.

THE WITNESS: I'm trying to remember. I'm not trying to answer a different question.

THE COURT: Okay.

THE WITNESS: -- as I recall, it was contiguity, equal population at 1 or 2 percent, a measure of compactness. I think he used the isoperimetric inequality -- no, no -- yes. He used that. And he also used a different measure of

1299

compactness.
He ran eight different chains. In some of them, he used some constraints and not others. He did this -- this series of "sometimes" I'm using this; "sometimes" I'm using that. Sometimes it was 2 percent; sometimes it was 1. Sometimes it was the isometric [verbatim] inequality. Sometimes it was, I believe, a perimeter test. Sometimes he used median/mean. And sometimes he used -- I think it was a variance of Democratic over Republican.
So there were a series of different -- different things that he used in different combinations.
BY MR. GERSCH:
Q. All right. But you understand that he's going to run -- or the way it works is he runs his test generating these small changes subject to constraints, which will be set out in his report, and that a districting, under his process, will be called "gerrymandered" if the overwhelming majority of districtings encountered in running the process are fairer, as measured by his chosen metric, than the current districting.

1300

That's the way this works, right?
A. I don't think he said fairer. I think he said is an outlier on some chosen metric.
Q. Okay. But he -- he's going to compare the enacted map to the maps he generates, and he's going to measure that by a particular metric, which is the median/mean?
A. Yes.
Q. All right. And just so we're using the same terminology used in your report, Dr. Pegden is going to generate, then, a lot of districtings which you refer to in your report as local districtings, right?
A. I did make reference to local redistrictings, yes.
Q. And the local districtings are the things that he generates?
A. Yes.
Q. All right. And both you and Dr. Pegden agree that the local districtings, however many billions there may be, are going to be a lot less than the total universe of all possible?
A. Yes.
Q. And all possible districtings, Dr. Pegden calls the "bag of districtings," right?

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A. Yes.
Q. All right. And -- and now we come to the key part.
What Dr. Pegden's theorem says is that you can take the results of what you called the "local districtings" and then make a statement about how the actual map relates to the bag of all possible districtings that satisfy his constraints?
A. Okay. Say that last sentence for me one more time, please.
Q. Sure.
Dr. Pegden's theory says that if you go through this process, you can take the results of the local districtings and then make a statement about how the actual map, the enacted map, relates to the bag of all possible districtings that satisfy his constraints?
A. Yes. And I have no problem with that characterization. My problem -- our disconnect is over how he then translated that to the redistricting context.
Q. Okay. But you -- the statement that I read, as far as you're concerned, it's perfectly right?
A. It's fine.

1302

Q. Okay. Good.
Let's, then, turn to the results that Dr. Pegden gets, and let's turn to Exhibit 122.
And, Dr. Cho, I'll just say this is the chart from Page 8 of Dr. Pegden's report, with the one addition that he's put row numbers on the far left side.
Do you see that?
A. Yes.
Q. All right.
A. I think those were in the original, weren't they?
Q. They're in his report?
A. Yeah.
Q. Yeah. Yeah. All we did is take this, blow it up and add the row numbers.
In your report, you don't take issue with any of these findings, right?
A. That's a very broad statement.
Are you saying I -- I accept all of these numbers?
Q. I'm saying there's no place where I could go to in your report where you say he calculated one or more of these numbers incorrectly?
A. Yes, that's true.

1303

Q. Thank you.

All right. Now, let's just take, as an example, Row 7, the second row from the bottom --

A. Yep.

Q. All right. And just as an illustration -- so that was done with a population threshold of 1 percent, a certain compactness measure. Dr. Pegden preserved counties. He froze District 2. And then he's going to report an epsilon finding which is 38 over 100 billion.

Do you see that?

A. Yes, I'm having a hard trouble counting the zeros, but let's say that's right, because it doesn't really matter.

Q. And what that means is that only 38 out of 100 billion districtings encounter -- districtings encountered in Dr. Pegden's computer processes show as much partisan bias as the actual map?

A. Yes, that's his claim.

Q. And you don't -- you haven't disputed any -- you don't say he got this wrong?

A. I don't dispute that he calculated that number according to the method at which he said he calculated that number.

Q. There's no place where I could find in

1304

your report where you say, These numbers are incorrect; there's no place in your report where you say, Those epsilon findings, while correct, don't mean what he says they mean?

A. I don't think that's correct. Because it's true I did not say that he calculated that number wrong. There's no mathematical error. I didn't say that. I did say that his interpretation of that number would not be my interpretation of that number, that his interpretation is overbroad.

Q. What page of your report would you point me to?

A. I think I say it at the end, the very last sentence, Pegden's --

Q. The last sentence of your report?

A. Yeah. Not the very last page -- the very last sentence, when I'm talking about his, on Page 17, I said, Pegden's unqualified claims are overbroad and do not match the analysis that he performed.

Q. That was supposed to disclose to us that you thought that the epsilon reported in this chart was overbroadly claimed?

A. Yeah, he makes claims based on these results. I claim those are overbroad, that he needs

1305

to qualify the claims; they're unqualified. If he were to qualify them, maybe they wouldn't be overbroad, but his unqualified claims are overbroad, and they do not match the analysis that he performed, which I did not say was wrong. I did not say, That number is wrong -- wrongly computed. I did not say that.

Q. Dr. Cho, my question, really, is about the disclosure point.

There's no place in your report where I could have gone and said, Oh, Dr. Cho is saying that these epsilon calculations are overbroad?

A. No, I did say that, because he makes claims -- this is -- I don't see how that's not encompassed in what we just read. He computes numbers. He makes claims. I said his unqualified claims are overbroad.

Clearly, those relate to this.

Q. I guess it will be a matter of debate whether it's clear or not.

The next -- let's go to the next column, which is the p-value.

Do you see that?

A. I do.

Q. And the p-value is what gets calculated

1306

as a result of his theorem, right?

A. Yeah, and -- and the epsilon value. He says this is how you count them.

Q. The epsilon value is calculated based on the random -- I'm sorry -- based on the local districtings that he generated?

A. But his theorem is -- says, this is what -- this is how you do this; this is how you do that.

Q. The theorem tells you how you get -- that you can get from the random -- I'm sorry -- the -- the local districtings to the bag of all possible districtings; isn't that right?

A. Yes.

Q. And the 38 out of 100 billion epsilon figure, that's actually what he generated as a result of running his machine?

A. Yes.

Q. All right. And you would agree that what the p-value means is that the probability that a randomly chosen districting from the bag of districtings will perform as poorly as the actual plan on his chosen metric is 28 ten-thousandths of 1 percent?

A. Yes, as he's defined his maps, as he's

1307

defined the chain, how the chain walks, as he -- yeah, as he has defined what he has defined in his paper, these are the numbers.

Q. And 28 ten-thousandths of a percent, that's a really strong p-value?

A. It is a small number, yes.

Q. You could get a new drug approved with a p-value at 5 percent?

A. Absolutely.

Q. A p-value of a tenth of a percent is considered highly significant in the social sciences?

A. It's debatable; but, you know, I wouldn't argue with that.

Q. This is a way smaller number than that?

A. It is a very small number. I agree with that.

Q. And Dr. Pegden's theorem has absolutely nothing to do with drawing a random sample, right?

A. Yes; he's not trying to draw a random sample.

Q. Right. There's no part of his theorem which says, In order to go to the next step, I need a random sample?

A. That's correct.

Q. That doesn't happen?

1308

A. Correct.

Q. All right. All right. I want to talk a little bit about the -- withdrawn.

MR. GERSCH: Can I consult with my colleagues just a moment, Your Honor?

THE COURT: Sure.

(Counsel confer.)

THE COURT: Can we go off the record for a minute?

MR. GERSCH: Sure, Your Honor.

- - -

(Whereupon, a discussion was held off the record.)

- - -

BY MR. GERSCH:

Q. Let's move on.

Dr. Cho, you say that Dr. Pegden should have imposed some additional constraints; is that right?

A. Yes.

Q. All right. You say he should have required the municipalities not be split; is that right?

A. Yes.

Q. You say that he should have required

1309

that incumbents not be paired?

A. He should have taken incumbency protection into account.

Q. Understood.

And you say he should require more stringent tests for equal population?

A. Yes.

Q. All right. Incumbents, we've already discussed. So you'll forgive me if I don't go back over that.

A. I would.

Q. Okay. Let's talk about population next.

MR. GERSCH: Let's put up Page 7 of Dr. Pegden's report, which is Exhibit 117, Petitioners' 117.

I may have the wrong page.

Let's try Page 8.

No?

Give me one moment.

(Pause.)

MR. GERSCH: That's it, Page 4.

And if you blow up that top bullet.

BY MR. GERSCH:

Q. All right. With respect to population

1310

-- and I'm just going to read this part into the record, Dr. Cho, and then I'm going to ask you a question about it -- Dr. Pegden reports that The small population variation in my comparison districtings cannot account for the extreme outlier status I encounter. For example, in my tests, my measure of partisan bias for a districting decreases by a factor of two or more after the sequence of swaps are made, not just by a few percent.

This means that even if the maps found by my method after many changes were altered to have equal (up to 1 person) populations, they would still exhibit less partisan bias than the initial maps.

Now, there's no part of your report, Dr. Cho, where you take issue with his computation there?

A. I'm unaware that there's a computation here.

Are you talking about the factor of 2?

Q. I'm talking about the fact that from his standpoint -- well, you say there's anyplace in your report where you take issue with this?

A. I take issue with the fact that this is a conjecture, not a statement of fact. It is expressed as a statement of fact. It is, in my

1311

opinion, a conjecture.
Q. You don't think he calculated this?
A. He is making a claim that if he goes to 0 percent, that there would be no change in the partisan bias. It's a conjecture. He didn't test it. He's making --
Q. Did you test it?
You could have tested this, right?
A. I could have tested it? You mean I could have taken all of his things and tested it for him?
Q. I'm asking you, You could have tested it, right? You could have taken his code, and you could have tested it?
A. I guess it's true. I could rerun the whole thing and tested it myself.
Q. Well, sometimes scholars do that, right?
A scholar will report: Fred reports the following 16, you know, observations; I ran his protocol; and, you know, I didn't find those 16 things.
That happens in scholarship, right?
A. That does happen. But, as I understand it, these runs took Dr. Pegden a week to two weeks,

1312

and I didn't even have that long to write the report. So this was not possible.
Q. Well, you could have run it for a shorter period of time, right?
A. I could not have replicated what he did.
Q. You could not have replicated what he did because?
A. No time.
Q. Did you ask for more time?
A. I'm not aware that that's -- I'm told, The Court works this way; your deadline is here; we have to file this. That's what I'm told. I'm not a pro enough at this to know if I had requested -- it did not even occur to me to request more time.
THE COURT: You wouldn't have gotten more time.
BY MR. GERSCH:
Q. Dr. Cho -- Dr. Cho, is it your contention that this isn't provable?
A. Is it provable or is it not?
Q. Yes.
A. I -- I suggested how to prove it, actually. I said, If you go and look at all the maps, how many of them are zero population, then you

1313

can make a claim.
Q. You have the maps, right?
A. I do not have the maps.
Q. The maps that he provided, do you have those?
A. No, I do not.
Q. Why not?
A. I was not -- this was part of the confidentiality agreement. As part of the nonconfidentiality agreement, Dr. Pegden supplied only a shapefile that is available to everybody on the Internet.
Q. So you chose not to -- to take the account maps?
A. Yeah, this confidentiality requirement was overbroad for me.
Q. And wholly apart from choosing not to take the maps, again, this is a paper in your field; it's been public for a year; and at no time did you want to investigate what this other scholar was finding that you seem to think is not quite right?
Do I have that right?
A. This paper -- the report has not been in the public. The paper which -- to make this claim about the zero population has been public, so I don't

1314

know why I would go check that because there's nothing to check in the paper. This is the report. This is a different claim that was made only in the report.
Q. In any case, so we can move on, you've not done any calculations to determine whether this is true or not?
A. I did not check that.
Q. All right.
MR. GERSCH: Can I have a moment, Your Honor?
THE COURT: You may.
(Counsel confer.)
BY MR. GERSCH:
Q. Dr. Cho, did you look at Dr. Pegden's testimony where he explained why this was true?
A. I did not.
Q. No one called it to your attention?
A. No one -- no one sent it to me.
Q. So when you say it's conjecture, it's conjecture for you, but you don't know whether someone else can explain why that statement is true or not?
MR. LEWIS: Objection.
THE COURT: What's your objection?

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MR. LEWIS: It calls for speculation. There's -- and there's no analysis that he provides.

THE COURT: Can you rephrase the question? It's -- there's a lot of negatives in there.

MR. GERSCH: Yeah, probably ill-formed.

I'll withdraw it.

BY MR. GERSCH:

Q. Dr. Cho, I don't know if anyone made you aware of this, but isn't it true that when Dr. Pegden went from 2 percent -- the 2 percent constraint to the 1 percent constraint, that the results he got were just as strong at a 1 percent constraint on the population as with a 2 percent?

A. That, I'm aware from his report, yes.

Q. All right. And isn't that suggestive of the notion that you're not going to get a big change going from 1 percent to 0 percent?

A. No, that's not obvious in the least. You're imposing a new constraint, and the new constraint is not obviously related to partisan bias in one way or the other.

Q. Well, may -- you may be saying the same

1316

thing, or maybe you're not.

The question is whether going from 1 percent to 0 percent is going to change his p-value.

Do you have any reason to believe that it will?

A. I have no idea. It wasn't done. And the way he defines his algorithm, it can't be done. He cannot run 0 percent.

Q. Well, I understand. But your proposition is that his results will be either wrong or not biased or not useful because he doesn't get to 0 percent. And my question -- my question to you is, You have not done any work to establish that, right?

A. The algorithm, as he defines it, can't even do that. So I don't even know what we're talking about. It's -- it's not even possible, the way he's defined his algorithm, to -- to produce those results.

THE COURT: Dr. Cho -- can I interrupt, Counsel?

MR. GERSCH: Certainly.

THE COURT: The question is, Why -- is the step from 1 to zero so significant that it just destroys his expert report

1317

because he didn't go to zero?

THE WITNESS: I'm not saying it destroys it. I'm saying, I don't -- I don't know what happens when you go to zero. It wasn't done. It can't be done. It's a significant constraint. It changes the results. We don't know in what direction.

BY MR. GERSCH:

Q. And you haven't done any work to try and figure it out?

A. I have not.

Q. Thank you.

Let's talk about municipalities.

You have a line in your report, I think you said on direct, that in the actual plan, 97 percent of the municipalities are preserved, by which you mean they're not split, correct?

A. Correct.

Q. It's 97 percent and change, to be fair.

A. Correct.

Q. Okay. And you say, This is an outcome not likely to be achieved by chance?

A. Correct.

Q. You did no work to establish that either, right?

1318

A. No, pure conjecture that if you preserve 97 percent, it's -- it's probably not by chance.

Q. Well, let's see.

Pennsylvania is a big state, right?

A. Yes.

Q. Not big like Arizona, maybe, but big compared to New Jersey, Maryland and those places?

A. I'll accept "big" without clarification.

THE COURT: At least in the top 10.

MR. GERSCH: Certainly.

BY MR. GERSCH:

Q. And you understand that most those 2,500 municipalities are going to be very small?

A. Small, big, it's a relative thing, right? It depends on the units you're using. If you're using census blocks, there's lots of census blocks in a municipality -- there can be.

Q. Have you looked -- have you looked to see whether most of those municipalities are very small?

A. Yeah, certainly a lot of them are very small --

Q. All right. And the district --

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A. -- without defining "small."
Q. -- the district lines, they're pretty narrow; they're also metaphysically narrow?
A. They are nonexistently narrow, right.
Q. Right. So we -- so we have a big state, we have a lot of small municipalities, we have very narrow lines -- by the way, relative to the number of municipalities, we have very few district lines, right?
A. Yes.
Q. You certainly wouldn't expect -- it would certainly be reasonable to expect that over 50 percent of the municipalities would be preserved by chance, right?
A. I'd have to run the -- the algorithm.
Q. Exactly. And you didn't do that?
A. That's correct. I didn't do that.
Q. All right. You have no idea whether 97 percent is or isn't such a big number as to suggest that it didn't happen by chance; you have no basis for that?
A. It is true I'm saying 97 is a lot. I also base it on, say, Dr. Chen's analysis, where he really couldn't preserve that many more. So if you're trying, you can't do much better. If you're

1320

not trying, I do not know; I would assume many more would be broken.
Q. Well, whether -- whether -- whatever Dr. Pegden said about what you just said has nothing to do with whether you have a basis for saying that 97 percent is a number not likely to occur by chance?
A. What did Dr. Pegden say?
Q. He didn't speak to the subject in his report.
A. So I can't say anything about him not saying anything?
Q. That wasn't my question.
You -- you have offered an opinion in this case that 97 percent municipality preservation is not likely to be achieved by chance.
You have no basis for saying that; isn't that right?
A. I am saying, cities are supposed to be preserved; he didn't preserve cities; the original plan preserved 97.3 percent of the cities; maybe he should have prevented -- maybe he should have preserved cities. He should have preserved cities. I didn't say "maybe." I said, He should have preserved cities. He should have tried.
Q. And for all you know, the cities are

1321

preserved in his maps, correct?
A. They could be.
Q. All right.
A. I know he didn't try, but they could be.
Q. Let's talk about the mean/median gap.
On direct, you suggested that maybe the mean/median test would vary for even small changes in the map, right?
A. Um-hum.
Q. That's a yes?
A. Yes.
Q. The reporter just needs an audible yes.
A. Yes.
Q. You also suggest that maybe a mathematical difference in the mean/median wouldn't necessarily imply a change in the number of seats held by each party, correct?
A. Yes.
Q. All right. You've done no work to determine whether your observation, if true, biases Dr. Pegden's results in a particular direction, right?
A. You mean -- explain that to me.
Q. Sure. I'll rephrase.

1322

You've done no work to determine whether this criticism you have, if true, would bias Dr. Pegden's results in favor of the map looking better or in the direction of making the map looking worse?
A. Yes.
Q. "Yes," you've done no computation?
A. "Yes," I've done no computations.
THE COURT: This is the risk of asking negative-phrased questions.
MR. GERSCH: Yes, it's getting later, and I should be better. What can I say?
THE COURT: I think it was "yes," you've done no work, right?
Dr. Cho; is that correct?
THE WITNESS: I've done no work.
BY MR. GERSCH:
Q. Thank you, Dr. Cho.
One composite that may be the fact that the mean/median measure is sensitive to small changes, that could make the map look fairer?
A. It's possible. In that case, I would also say it was meaningless.
Q. Dr. Cho, you could have run his --

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Dr. Pegden's code to measure what seats would change, as opposed to the mean/median gap, couldn't you have?

A. I'm -- I think that would require me to edit his code.

Q. He gives instructions on how to do it, doesn't he?

A. I don't need instructions on how to do it. I'm just saying that would require me to do it. I can do it.

Q. Okay. But he said -- he makes it easy; he tells people how to do it, publicly?

A. I really -- I didn't see these instructions, but I'm not looking for instructions on how to edit his code.

Q. You -- you didn't look? You didn't look to see?

A. For instructions, no, I did not.

Q. And you didn't look to see if he said, Yeah, you could -- if you wanted to check out seats, you could check out seats?

A. I don't need him to say that; I know you can do that.

Q. All right.

MR. GERSCH: I think I'm almost done, if I can just confirm and make sure.

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THE COURT: Please.

(Counsel confer.)

MR. GERSCH: Just a few more questions, and I'll wrap up.

THE COURT: Proceed.

BY MR. GERSCH:

Q. On Page 24 of your report, you raise the issue -- you said, My supercomputer algorithm can generate better maps, and then you go on, correct?

A. Yes.

Q. You have, as I understand it, at least one, and I think I understood you from your testimony to have multiple approaches to measuring whether a map is gerrymandered.

A. I have -- I don't know what that means. I -- I run simulations. I don't know that that's multiple approaches.

THE COURT: I think you testified that you have multiple measures of partisan bias.

THE WITNESS: Yes. That, I do.

BY MR. GERSCH:

Q. All right. But you have an approach, you have a measuring stick, if you will -- withdrawn. I'll go back a step.

1325

I watched the Vox --

A. Yeah, video.

Q. -- video of yours.

You say you have a measuring stick that's intended to help the Supreme Court determine whether or not maps are gerrymandered, right?

A. Yes.

Q. All right. And you run that on your Blue Waters really fast computer, right?

A. Yes, the supercomputer.

Q. And by "supercomputer," what you mean is it has a lot of computing power?

A. It's a massively parallel architecture.

Q. And you say it's the fastest computer -- what, in the world? In North America?

A. It is the fastest research supercomputer in the world, which means it's the fastest supercomputer that's available for research.

China, for instance, has a supercomputer that is faster. It's not open for research.

On Blue Waters, anybody -- anybody in this room could propose a grant of time to use the supercomputer. That's what I mean by a research supercomputer.

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Q. And when you use your approach, your measuring stick, on this computer, you generate lots and lots of maps, right?

A. I do.

Q. And you say that yours is the best approach, right?

A. I like; I'm partial to mine. There are advantages and disadvantages.

Q. As any scholar should be, right?

A. Excuse me?

Q. As any scholar should be, right?

A. I guess, sure.

Q. But you did not choose to employ your method on the fastest computers we can use, what you say, what you think is the best method, you chose not to try and determine whether Pennsylvania's 2001 Map is a gerrymandered map?

A. You're asking me if I did my own analysis of Pennsylvania?

Q. I'm asking you exactly what I asked, whether you used what you think is the best approach, using the best computers, to evaluate whether or not Pennsylvania's map is a gerrymandered map?

A. I did not -- I did not complete an independent evaluation.

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Part of this -- there are two reasons for that. One, I wasn't asked to; two, this is a very involved process. This isn't a thing where you double click on something and the analysis is run.

If I were to complete an analysis of Pennsylvania, it would require significant amounts of my time. I could not complete it in a week. I couldn't complete it in two weeks. In fact, I was asked to do that analysis. And this is exactly what I told the people who asked me, is that a week would not be enough time for me to complete this analysis.

Q. Well, Dr. Cho, no one limited you to a week, right?

You -- you -- what you've chosen to do or what you were asked to do was to respond to other people's reports, but if you had wanted to run your own analysis, you didn't have to wait for their reports to come in; you could have started months ago?

A. This is absolutely true. I could also run an analysis of -- of other things, but I'm a very busy person. I -- I -- I'm a professor. I have a lot of demands. I'm teaching. I home school my children. You know, I have a lot of things to do, and this was not one of them, especially -- it's an

1328

optional thing. It's not . . .

When I rank the number of things I have to do today, this is not on top.

Q. I hear you.

So just to summarize, you're here to criticize Dr. Pegden; you're here to criticize Dr. Cho -- Dr. Chen -- my apologies; again -- but you didn't run Dr. Chen's code, you didn't run Dr. Pegden's code and you chose not to run your own chosen method, the method you think is the best out there, right?

A. If I thought I needed to run their code to formulate the opinion I've formulated, I would have run their code. I don't think not running their code in any way changes what I would have said.

I think -- again, as far as doing my own independent analysis, I could have done my own independent analysis. I -- in fact, it is on my list of things to do, to run an independent analysis of the entire country. I would like to do that at some point.

But on my list of things to do as far as the supercomputer and my algorithm are actually a lot of things that come way before that. And one of them is improving my own algorithm. Another one is

1329

improving the operators, the efficiency within my algorithm. There are a lot of things that are actually, in my opinion, more important to do than that.

Q. Dr. Cho, you didn't do any of the three things I listed?

A. That's correct.

MR. GERSCH: No further questions, Your Honor.

THE COURT: Redirect.

MR. LEVINE: Wait, Your Honor. I have cross.

THE COURT: Okay.

Respondent -- another Respondent is going to cross-examine the witness.

MR. LEVINE: Excuse me. I am just going to reference the -- what is it? -- Exhibit 252, I believe -- is that the article?

MR. GERSCH: I believe so.

MR. LEVINE: Would it be possible --

THE COURT: Petitioners' Exhibit 252.

MR. LEVINE: Thank you.

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CROSS-EXAMINATION

BY MR. LEVINE:

Q. Professor, my name is Clifford Levine. I'm counsel for the Lieutenant Governor of Pennsylvania, who is a party in this case.

I had a few questions specifically about this article that was referenced earlier, Toward a Talismanic Redistricting Tool: A Computational Method for Identifying Extreme Redistricting Plans.

This was an article that you wrote and had published in 2016 in the Election Law Journal -- the Election Law Journal; is that correct?

A. That's correct.

Q. And this is an article -- was this a peer-reviewed article?

A. Yes.

Q. And in this article, you are -- looking at the next page, Page 352 -- you are proposing -- on the right column in the -- in the first paragraph, you're proposing, basically, a study of determining, in this situation, whether any entity that use -- utilizes voting data from partisan races is likely

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conditioning state action on speech. While the Court recognizes that a redistricting plan might need to treat political parties differently in order to achieve other important state goals, these infringements should be limited and not excessive.

Do you see that portion?

A. I do.

Q. So you were just setting the framework -- you were referencing a challenge to the Maryland Congressional map; is that correct?

A. I was not issuing a legal opinion on Maryland. I was using Maryland has an illustration and proof of concept of my method.

Q. Okay. Were you engaged as an expert witness or consultant in the Maryland litigation?

A. I was not.

Q. Okay. So you were looking at Maryland as an example, and you were noting that the Maryland case involved both a First Amendment claim and a 14th Amendment claim?

A. I was not making a statement about whether it did or not. I said it's possible you could take a First Amendment route; it's possible you could take a 14th Amendment route; it's possible you could take other routes. I was not issuing an

1332

opinion on -- on that.

Q. Okay. And at the lower portion of the -- that column at the bottom of the second-to-last paragraph, if you see that, it says, An analytical mentioned -- you're describing how -- you're proposing, really to the academic community, how we should go about making an analysis of gerrymandered maps, I take it.

And you say, An analytical method needs to be able to separate natural consequences arising from particular population concentrations from state-imposed disparate effects that bestow an unnecessary political advantage in favor of one group over another.

Do you see that?

A. I do.

Q. Okay. Just so I understand it, you were saying basically this analysis is to try to make a comparison between what might be the natural element -- or what you later referred to as core legal elements of gerrymandering, such as compactness, contiguity, et cetera, with partisanship.

Is that what you were referencing?

A. That's basically correct.

1333

Q. Okay. And then later in the report, on Page 354 -- on 354 on the right column, about 10 sentences down, you indicate that Usually, there is a core set of criteria that includes population, equality, contiguity and constraints on compactness in preserving communities of interest, cities and counties. Of course, it is an uncontroversial claim that the considered map satisfy all legal criteria. No one would claim otherwise.

Do you see that?

A. Yes.

Q. So you were suggesting that in doing an evaluation to determine whether there was partisan gerrymandering associated with the design of a legislative map, that those were factors that would be the core factors and that, really, they would not be particularly controversial if someone were to evaluate those particular core factors, correct?

A. Yeah. So people were considering population, equality, contiguity, compactness, preserving communities of interest. That -- this is generally not a controversial thing.

Q. All right. And then you went ahead and you did an analysis. You did simulations of the situation in Maryland, right, you were comparing

1334

Congressional districts?

A. Correct.

Q. Now, this was a reverse situation that we have here in that the allegation was that the Democrats had created a very partisan gerrymandered map in Maryland, correct?

A. Correct.

Q. And so you did a number of simulations, and then you looked at your simulations and you compared them to the actual Maryland map; is that right?

A. Correct.

Q. And based on your simulations, you reached a determination -- at the very bottom of Page 360 on the right column, you reached a determination at the very last four sentences, In fact, of the set of reasonably imperfect maps, our algorithm identified, without using any partisan data whatsoever, 94.79 percent of the generated maps were more responsive to changes in the vote proportion than the current map.

And then you concluded, This implies that partisan considerations were likely at play in devising the current map, since creating a map with its level of responsiveness is unusual, though

1335

possible, when partisanship is not a factor in the map creation.

Is that right?

A. I see that, yes.

Q. So, in other words, you took the simulations -- you looked at the simulations, you compared them to the map, and you viewed the Maryland Congressional map as somewhat of an outlier compared to your simulations, and that 97 or 96 percent -- I'm sorry -- 95 percent or so were more competitiveness?

A. That's the idea.

Q. Okay. And then you also reached a conclusion at the bottom of 362 where you look -- you did the same analysis, and you concluded that 87-1/2 percent of the simulated maps were -- I believe, resulted in more competitive -- more competitive elections; is that right?

A. I don't see it, but I'll take your word for it.

Q. I'm sorry. Take a look. That's the bottom of Page 362 --

A. That's fine. I did something like that.

Q. So that's -- that's the analysis that you undertook, right?

1336

A. Yeah.

Q. Okay. And then on Page 364, two-thirds of the way down, it's -- there's a sentence, These histograms -- These histograms --

MR. LEVINE: Thank you for assisting. I appreciate it.

BY MR. LEVINE:

Q. -- These histograms -- do you see where that starts?

A. Um-hum.

Q. -- These histograms provide evidence that under a First Amendment framework, the map has encroached one party in favor of the other and that these infringements were the result of the explicit consideration of party, not necessitated by the population landscape.

A. I see it.

Q. Okay. And then you -- so you have reached the conclusion that making these comparisons of the simulations, you could conclude that there were motivations associated with that map that indicated a partisanship bias?

A. That it's possible, yes.

Q. It was more than possible; it was likely.

1337

Would that be fair to say?

A. I can let you go where you're going and then wrap up, if you want, or I can make --

Q. I'm just asking you based on -- if you're saying that the 95 percent -- I believe you're looking at the -- your various simulations, and I believe you conclude that these histograms provide evidence that under the First Amendment framework, the map has encroached one party in favor of the other.

So that was your conclusion, was it not?

A. Right. So -- so this -- this paper was written in response to a contest by Common Cause to propose ways to measure gerrymandering. So that -- that's where this paper originated.

And it -- it -- the contest that year insisted that you either look at Wisconsin or -- or Maryland, and we chose to look at Maryland.

But I was very careful, I think, in this paper to not issue a legal opinion, as it were. And if you look at the analysis, the analysis considered only contiguity, compactness and this -- this measure of competitiveness, which, in my opinion, would not be sufficient for making a -- a

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legal claim in exactly the same way that I am saying that Dr. Pegden and Dr. Chen's analyses are not appropriate.

Because I did not go back and look at the Maryland map in -- in -- in detail, try to figure out what the legislature actually used. I didn't actually go and compile all the data that would be necessary for that analysis, partly because I'm not issuing a legal analysis, and partly, it was -- it was also a time issue.

I -- this thing was due at midnight, and I had I don't know how many things to do that day. I submitted this one minute before midnight --

Q. I'm sorry, Dr. Cho. You're submitting a peer-reviewed --

A. No, no; for the contest. Later, it was submitted to be peer-reviewed.

Q. But then you submitted a peer-reviewed article in a prestigious journal, right?

A. Yes.

Q. And -- and the title is Toward a Talismanic Redistricting Tool --

A. Yes.

Q. -- you are speaking to the entire academic community --

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A. Yes.
Q. -- and to the world and telling them here's how we can improve and here's how we can do an analysis in partisanship analysis, right --
A. Yes, absolutely.
Q. -- that's what you're doing.
And when you did the analysis here, you didn't consider the Voting Rights Act as part of your analysis; isn't that true?
A. That's true.
Q. And you didn't consider the preservation of incumbency when you were ascertaining whether the Maryland map was -- was gerrymandered; isn't it true?
A. Absolutely.
Q. And, in fact, in your article, you did make the statement --
MR. LEVINE: If you could go to 356 -- Page 356, Column 1, right in the middle.
BY MR. LEVINE:
Q. -- follow-up on a point that you were having a discussion -- a long paragraph. So it says, Holding entire districts together -- do you see that? It's about 12 sentences down.

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MR. LEVINE: I appreciate that.
About halfway to the right.
BY MR. LEVINE:
Q. -- Holding entire districts together from a disputed plan is an even more questionable choice when the objective is to analyze the fairness of a plan.
A. I see it.
Q. All right. And then you say, Holding entire districts together from a disputed plan is an even more questionable choice when the objective is to analyze the fairness of the plan.
So that is -- that if the plan was -- if you started with a map that was controversial or in dispute or, itself, was gerrymandered, then your view in terms of coming to the appropriate way to do this analysis would be not to rely on that plan as a starting point, right?
A. No. This -- this phrase here is -- if you go back up -- is in reference to Chen and Rodden holding Voting Rights Acts districts frozen and then simulating around it. Not only do they hold the Voting Rights Acts frozen, they held frozen the exact same cities that were held constant in the map in question. They held the exact same counties.

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That approach, I think, is -- is what I'm referring to there.
Q. Okay. So you're saying that you would prefer to start from scratch there and start the analysis rather than holding cities or voting districts if you felt they were part of an unfair design?
A. No. It's a different point. The point is in the map, there were -- I forget how many cities were not broken. And when they did the analysis, they held those exact same cities together. They held those exact same counties together. They held most of the map frozen when they did their analysis.
And I said, You don't hold most of the map frozen when you do an analysis. That's what I'm saying.
Q. Okay. Now, you have a discussion on Page 364 of your article about the Voting Rights plan and why -- you indicate that you did not include that in your analysis of the Maryland district. And then you indicate three reasons.
And essentially, you're saying this area of law seems to be in flux, so it's harder to definitely measure that and include that in your simulations.

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Is that essentially what you're saying?
A. Tell me what you're reading.
Q. Page 364 in the right column.
A. Can you highlight it for me? I can -- I neither can read it nor know what you're referring to.
THE COURT: Mr. Levine, what are you referring to?
MR. LEVINE: I'm sorry. There's a discussion on the Voting Rights -- she indicates that --
THE COURT: She wants to you direct her where you are.
BY MR. LEVINE:
Q. Page 364, the right column at the top of the page. We omitted this analysis for three reasons, i.e., the Voting Rights analysis.
A. Okay.
Q. Okay. And I'm just saying -- I'm summarizing. You go through it, but it -- basically, you indicate that there's some confusion, some uncertainty, it's harder to define, there's no explicit clarity on that issue.
A. Yeah. So this paper discusses partisan gerrymandering. So this first point, it says -- you

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know, all I'm trying to do in this paper -- I'm not issuing a legal opinion; all I'm trying to do is show proof of concept, that here's a method, this is how it works, this is how you could use it.

I'm not saying use it this way. I'm not saying here's an analysis for Maryland that I think should go to court. I'm not saying any of that.

This is a proof of concept. I'm describing the tool. I'm describing how one might use it.

Q. All right. And you were able to conclude, based on looking at the tool -- and I'm not talking about a legal level -- you were able to reach a conclusion that in Maryland, there was actually -- partisan gerrymandering influenced the process --

A. No.

Q. -- based on your analysis?

A. No, I was not able to do that.

Q. You were able to conclude that the -- generally that the existing map differed significantly from the simulations that you had produced, and you could draw some conclusions from that?

A. No, I did not, and I did not.

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Q. All right. So when you say, These histograms provide evidence that under a First Amendment framework, the map has encroached one party in favor of the other, and that these infringements were the results of an explicit consideration of party, not necessitated by the population landscape --

A. Right. I understand what you're saying, and I understand how you're reading it. And what I'm explaining to you is it's a proof-of-concept paper. Here's a concept, here's how you would use it. And I'm explaining to you, then you can draw these histograms, then you can make these kinds of conclusions.

I'm not saying I'm making those conclusions; I'm saying this is how you use the tool. It's a proof-of-concept paper.

MR. LEVINE: Thank you. I have no further questions.

THE COURT: Does anybody else on the Respondents' side wish to cross-examine the witness?

MR. FREEDMAN: No, Your Honor.

MR. TABAS: No.

THE COURT: Redirect, please.

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MR. LEWIS: Just a quick moment, Your Honor, to gather my thoughts and I'll -- Court's leave.

(Pause.)

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REDIRECT EXAMINATION

- - -

BY MR. LEWIS:

Q. All right. Okay. Dr. Cho, you were asked a series of questions in reference to Dr. Chen's expert report concerning the subject of the maps that had the 56.8 black voting-age percentage or not. Just a couple very quick follow-ups.

Dr. Cho, when you run simulations of districts, how do you account for Voting Rights Act compliance issues, including whether a majority-minority district would need to be created?

A. We're still working on that, actually. But the way we're working on it, we try to do that analysis as a separate analysis, not as a -- because it requires -- when you have it in an algorithm, it's -- it's a separate consideration that doesn't work together with the other ones at the same time.

I don't know -- it's a little bit hard

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to explain, but I think you satisfy one -- the -- racial gerrymandering is a completely different set of criteria. And it's hard to mix the two because sometimes they're in conflict with each other.

The interplay between racial gerrymandering and partisan gerrymandering, that's another issue. It's something I've been thinking through. I'm not -- I don't have a final thought on that.

Q. But are there any commonly used or generally accepted methods that people who run these simulations, whether you or others, use at least as a proxy for whether Voting Rights Act issues are accounted for?

A. So -- so Dr. Pegden froze the district that -- District 2, which he considers a Voting Rights Act district, I assume. And Dr. Chen ran his simulations and only took out the ones that had -- had at least the same percentage of minorities --

Q. Okay.

A. -- those would be proxies.

THE COURT: Dr. Cho, that wasn't the question.

The question was, Is there a

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generally accepted proxy in the industry that can be used?

THE WITNESS: Ah. I wouldn't say there's a generally accepted proxy.

BY MR. LEWIS:

Q. Did you assume, in preparation of your report, that Chen was attempting to use the 56.8 percent black voting-age population as a form of a proxy for Voting Rights Act compliance?

A. I very -- I thought that was clear that that's what he was doing.

Q. And is that the reason why you threw out all but 54 of his maps?

A. Yes.

Q. I'd like to return briefly to Dr. Pegden's table, which has been marked as Petitioners' Exhibit 122. We've put it up on the screen.

Dr. Cho, you were asked a series of questions about the epsilon value for partisan bias and its significance.

What is the basis of your -- is the basis of your disagreement with Dr. Pegden the ability to draw conclusions from these results about whether Act 131 is an outlier with respect to the

1348

entire universe of possible districting maps in Pennsylvania?

A. Yeah. I think the essence of our difference is that because he didn't -- he doesn't have the criteria that he needs to have when he created his maps; this claim is overbroad. I don't know how overbroad it is, but it's overbroad.

So, for instance, if he was, you know, switching VTDs, and the VTDs' broke cities, that wouldn't -- for his algorithm, that's not a big deal. But if he had tried to preserve cities, then he would have tossed out that map.

And it's -- it's -- it's -- it is not easy to find legally valid maps. And to find them by doing a one shift of a VTD, in my opinion, is -- not worked very well.

So let me give you an example from my work. I have an operator that does a one -- a one-shift. And I can complete -- so I'm not bragging here, but I can complete a trillion in about 10 seconds of time on the supercomputer. That's how long it would take me just to do the movement and to compute the new -- the new things.

For me to compute a trillion valid maps would take me approximately, with more than 100,000

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processors, let's say, on average, if it's -- if it's, on average, difficult, about three hours. I have never reported an analysis that took me 10 seconds on the supercomputer. I don't think that's enough computation.

It's a hard problem. Most of the analysis that we produce, even this one for Maryland which I considered not a -- a completely valid -- legally valid analysis, took us, I want to say, 131,072 processors running for four hours to find the maps that we reported.

And we don't report a trillion maps. I have to look again at that one, but I think it was 200,000 maps. And that -- that's the difference in computation. That's how long it takes to find these maps. It's -- it's not easy. It's really -- it's really a difficult process.

Q. And, Dr. Cho, just one last question.

There's been a lot of talk today about whether you could have analyzed any code or, you know, data that were used in -- in connection with the expert reports issued in this case.

Could you have performed any review of code or -- or data produced in this case before you received them -- before the reports were issued, I

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should say?

A. Could I have looked at the code before --

Q. I mean, the code or the data that were used that Drs. Chen and Pegden relied upon for their data -- or relied upon for their reports, you couldn't have even started that process until after the reports were served, right?

A. After their reports were served?

Q. Yes.

A. Well, I didn't -- I didn't even know who -- who they were going to be until I got the reports.

Q. Okay.

MR. LEWIS: Your Honor, we have nothing further.

THE COURT: Okay.

Dr. Cho, thank you for your testimony. You may step down.

(The witness was excused.)

THE COURT: Mr. Gersch, how long do you need to prepare Dr. Pegden?

MR. GERSCH: We'd like as much time as we can. We'll need at least an hour.

And we'll have a short motion now.

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THE COURT: Okay. Well, let's do the short motion.

MR. GERSCH: Your Honor, we're going move to strike testimony of Dr. Cho.

THE COURT: In its entirety?

MR. GERSCH: Yes.

THE COURT: Okay.

MR. GERSCH: The basis is she just didn't do the work. It's not, we submit, a generally accepted methodology to offer expert opinions about other people's work without looking at their work.

And this is not excused by feeling that it will compromise your academic principles, and I don't say that to demean anyone's academic principles. I say that if you want to be an expert, you sign on for looking at other people's work.

It's also not excused because you have other important things to do. And, again, I certainly wouldn't question that there are people who would think they have more important things to do than be here. I can easily imagine that. But, again, if you sign on to be an expert, you need to do the

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work.

Dr. Cho didn't look at Dr. Chen's code. She didn't look at Dr. Pegden's code. She chose not to run her own methodology on any number of situations. She made criticisms of the work of our experts where it turned out she had done no work to support her views: no computation, no analysis.

She says, Cities were preserved at 97 percent, it's not likely that would occur by chance, but she's done no work for it.

She says you've got to throw out Dr. Chen's maps because they don't comply with the legal requirements of the VRA, but she's done no work for it.

And -- and the notion that that's excused by saying, Well, I read Dr. Chen to say that the VRA was required -- Dr. Chen didn't say that.

There's also the disclosure point, Your Honor. She -- she quibbles with Dr. Pegden's report of his epsilon values, and she says this was disclosed to us in this very, very general statement that I

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think most people would say was opaque boilerplate.

And I want to say here, Your Honor, we recognize we have a heavy burden in making this argument. I think Your Honor has made the point on occasion that there's an importance to preserving the record for the Supreme Court, and we get that, we get that. But in the case of this expert, she just didn't do any work. All she did was criticize and offer what essentially are conjectures.

We're not saying that she's not qualified as an expert in redistricting, we're not saying she's not qualified in simulating maps and those things, but she didn't do the work.

THE COURT: Thank you.

MR. GERSCH: Thank you, Your Honor.

THE COURT: Legislative Respondents.

MR. LEWIS: Your Honor, Dr. Cho has worked in the field of redistricting and has worked with simulations and algorithms for more than 20 years. She has published. She

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teaches. She's been engaged in scholarship for all that time.

She has extensive experience and qualifications to be evaluating the algorithms and the methodologies that are employed by Plaintiffs' experts in this -- or Petitioners' experts in this matter.

It is not for Dr. Cho to necessarily disprove every single -- every single minute element of the claim. It is, in fact, the Petitioners' obligation to use -- to the extent that they are relying on experts, that their experts are using rigorous, theoretically supported, accepted methodologies for their -- for their reports.

Dr. Cho has testified based on her extensive training and experience that the model of algorithm employed by Dr. Chen was not suitable to the task at hand and that review of the code -- the specific source code that Dr. Chen's computer used when it drew the -- the -- it operated the Etch A Sketch and drew the map would not have affected her -- her fundamental criticisms

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and opinions.
To the extent that they want to quarrel with whether she looked at the code or did not look at the code, at best, that goes to -- to weight. And we would argue very little -- it should -- it should barely be considered, if at all, as a factor.
The concept that she did no work ignores all of that experience that she's accumulated over 20 years of doing this work. The fact that her article -- you know, she's written, published many, many times on these subjects. The reference list on her -- the list of publications and citations to accepted scholarship in the field is very lengthy, of course, in her CV, which is over -- which is 12 pages long, and as well as in her report.
The idea that she just sat down and banged out a report without doing any work is -- is not reasonable, and it's not fair to the analysis that she performed.
Let's talk about a few of the items.
There's a comment, for example, about an argument with a statement -- a

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conjecture she made that 97 -- the fact the map preserves 97 percent of the municipalities was not done by chance.
I don't think anyone meaningfully disputes in this case that preservation of municipal lines and municipal boundaries is a traditional districting principle. In fact, Dr. Chen -- expressed that opinion in his own report. This is not a meaning -- the materiality of that -- of that question, whether it's 97 percent, was it by chance or not, is, quite frankly, irrelevant.
The real thrust of her criticism on the 97 percent issue was the fact that municipal lines are a traditional districting criteria. And if your goal is to say that, as Dr. Chen and Dr. Pegden -- in this case, Dr. Pegden's goal is to say that Act 131 is not like the others, her point is to say, then, you have to draw the others like you would expect Act 131 to be drawn. And due to traditional districting criterias, that involves municipal lines.
With respect to --

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THE COURT: Doesn't that also, to a certain extent, assume that the General Assembly drew this map consistent with traditional districting principles?
MR. LEWIS: Well, that's not the -- that's not the analysis, Your Honor, that Plaintiffs have -- have employed in this case. What they're saying -- they're saying -- their analysis, both Chen and Pegden, as I understand it, is to say "assume away the precise factors the General Assembly actually considered."
We're going to say there's traditional principles of contiguity, equal population and minimizing city and county splits. And assuming that -- so we're going to give the Legislature the benefit of the doubt. They did A, B, C and D. Those are traditional factors.
This map is not like the others. If that's the case, then you need to employ the traditional districting criteria. That's the argument. Because their conclusion that this is not like the others on the measure of partisan bias, their conclusion is that

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means there was deliberate partisan bias -- well, all partisan bias, I suppose, is deliberate.
They can't do that if they're not controlling for the factors. That was the thrust of Dr. Cho's criticism.
With respect to the issue of -- you know, this epsilon value, I frankly don't even understand the argument. She -- her point is the ability to generalize from the conclusions. Her point is not to quarrel that when Dr. Pegden ran his Markov chain, that he was able to demonstrate that this map was not like the maps in this bag.
Her point was to say, Well, maybe you've shown that. The question is, Is this bag -- this bag of districtings that this one is not like, is this really the universe of possible districtings exclusive of the question of partisan bias. That was her thrust.
So talking about did she disclose in her report a dispute on an epsilon value is really immaterial. Her -- the thrust of her criticism is absolutely, unmistakably clear

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in her report. She goes on for, what, at least 13 or 14 pages criticizing the methodology and the application of the theorem to the redistricting problem. And her conclusions, as she's testified to today, are entirely consistent with that report.

So on that basis, we believe that there's not a basis to exclude her testimony, that she is adding value to -- certainly is adding a lot of value, a lot of -- a lot of expertise to this process that the Court should consider.

So we would request the motion be denied.

THE COURT: The Court thanks the parties for the arguments.

The motion is going to be denied.

The arguments are on the record. The Court certainly -- this Court, in crafting its findings of fact and conclusions of law, will give the testimony appropriate weight, if any, after reading the transcript and considering the parties' posttrial findings.

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And, of course, you are free to argue whatever you want to argue to the Supreme Court if you think the Supreme Court should completely disregard Dr. Cho's testimony. Or, vice versa, if any of the other parties think there should be a disregard of other testimony, I'm assuming you'll have that opportunity. But I am not going to strike the testimony from the record.

Going back to the question, you need an hour to prepare Dr. Pegden?

MR. GERSCH: As I said, Your Honor, we'd like at least an hour.

THE COURT: Do you have -- so since -- I hesitate to ask the next question.

How long do you think of a redirect you're going to need? Again, usually, redirects are pretty brief.

MR. GERSCH: Agreed totally, Your Honor.

I'm being told under an hour.

THE COURT: Okay. So if I give you until 5:30, we can be done by -- well, let's see if I got that right.

What time is it now? I think we're coming up on 4:30, right?

So if I give you until 5:30 to prep Dr. Pegden with redirect, we should be out of here by 7:00 at the latest?

MR. GERSCH: That sounds right to me, Your Honor.

THE COURT: Okay. We will go into recess until 5:30.

THE CLERK: The Court is now in recess.

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(Whereupon, a recess was taken from 4:25 p.m. to 5:32 p.m.)

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THE CLERK: Ladies and gentlemen, the Court is now in session.

THE COURT: Please be seated, everyone.

As I indicated earlier on the record, we're going out of order here in order to move things along. So I've asked Petitioners if they have a rebuttal witness that they could present.

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So Petitioners, would you like to present a rebuttal witness at this point?

MR. GEFFEN: Yes. Petitioners will call Dr. Pegden as a rebuttal witness.

THE COURT: Dr. Pegden, please approach.

WESLEY PEGDEN, PH.D.,

after having been previously duly sworn, was examined and testified further as follows:

THE COURT: Mr. Turner likes to make sure people really understand they're under oath.

So you've been sworn twice now.

THE WITNESS: I'm well aware. I really enjoy being under oath.

THE COURT: Please proceed.

REBUTTAL - DIRECT EXAMINATION

BY MR. GERSCH:

Q. Hello again, Dr. Pegden.

Dr. Pegden, you were here in the courtroom earlier today while Dr. Cho was testifying?

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A. Yes, I was.
Q. Dr. Cho testified about Figure 1 of her report.
MR. GEFFEN: If we could pull up Legislative Respondents' Exhibit Number 11.
Yeah, zoom in on that, please.
BY MR. GERSCH:
Q. And she used this figure that we're looking at here to illustrate that your trillion simulated maps on the left are just a local region within -- within a larger universe of districtings on the right.
What's your reaction to that criticism?
A. Okay. Yeah -- and first, let me just apologize for various ways in which this is an imperfect representation of redistricting, for example, there only being four neighbors, because this was really just a figure from the general Markov chain part of our paper. But still, it's a good illustration.
So as you said, she claims that we can't use just this local space to draw claims about the larger space, but this indeed is precisely the point of our theorem.
Q. And what do you mean by the point of

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your theorem?
A. Our theorem allows us precisely to conclude that a particular state in the Markov chain -- so that's a particular configuration -- is unusual with respect to the entire space even if it's gigantic, of an unknown size, many of its characteristics might never be known just from a local exploration.
This really was the breakthrough of our paper and why it was published in a prestigious journal.
Q. Both you and Dr. Cho have talked about this in terms of a restaurant and a taxi driver analogy, and I wonder if you can explain this for us in terms of that example.
A. Yeah. So bringing it back to that example -- right. So we imagine that maybe, you know, you've landed in -- in a new country you've never been to before, possibly a new city, you know nothing about the city or what the restaurants are like there.
And, again, so the example that I offered the other day was that you offer your taxi driver a large tip in exchange for taking you to a random -- a typical restaurant in the city, okay, and

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the taxi driver does. So he takes you to what he claims is just a random restaurant in the city.
You, unfortunately, describe that the food there is terrible, according to whatever metric you use to evaluate food, which may be how spicy it is or how large the portions are, whatever metric you've chosen, and moreover, you discover that when you start wandering around this restaurant where you were dropped off, the restaurants are all better than this restaurant that you were first left at.
Okay. So in this situation, you could view the figure on the left as being what you discovered happened to you when this taxi driver left you at a restaurant. So here, this green restaurant is one that's unusually bad. Maybe the food is unusually green. And when you wander around the city, you discover that this is less the case for the restaurants in the neighborhood.
And the point of my theorem is even though it's true that this local exploration does not allow you to somehow characterize the distribution of restaurants in this unknown city -- it's true you have not explored the whole city, I don't know how many restaurants there are. Do a lot of them have green food -- I don't know how many of them have --

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have green food, for example, but what I know for sure is that it is atypical for a restaurant in this city to be -- to have bad food, according to my metric, and to be surrounded by a bunch of restaurants with better food.
And actually, Professor Cho's figure on the right here, where she has modified my figure, is a great illustration of this. I almost wish I had used it in my paper. So what she did on the right here -- it's a little hard to see because the dots have become so small, but she took -- is my pointer working? -- she took this figure here and then created this tiling of it where she just repeated it over and over again.
Okay. And this has the effect of creating -- all right, so each little tile there then has one of these weird restaurants that is so much worse than the restaurants surrounding it. Okay?
But, nevertheless, even doing this, when I throw a dart at her figure -- not mine, but her figure -- you'll see that it will hardly ever land at one of these green dots in the middle of red dots. It will hardly ever land at a bad restaurant in the middle of good restaurants. And so -- and this is the case where this green dot is only an

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outlier in a relatively weak sense. There's maybe -- I don't know. How many pink dots are there -- but hundreds of dots around it.

And the numbers we see in our redistricting analysis are much more extreme than this.

Q. And just to close the loop on this analogy -- and apologize if this is -- if I'm asking you to state the obvious here, but in this analogy, your metric for deciding what a bad restaurant is, maybe, you know, which one has the tiniest portions, what is that analogous to in your redistricting analysis?

A. That would be the median/mean metric for partisan bias.

Q. And the green dot, or the restaurant you got dropped off at, what is that?

A. So that's the districting that the mapmakers dropped all of us off at when they made the map.

Q. And the taxi driver is?

A. The taxi driver, they are the mapmakers that drew this map, yeah. And my conclusion is that the taxi driver did not do what he claimed.

Q. And what he claimed was?

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A. To drop us at a typical or random representative restaurant.

Q. Okay. Moving on, Dr. Cho also testified that there is something special about redistricting that makes your approach to identifying outliers not well-suited to analyzing redistricting in particular.

What's your reaction to that criticism?

A. Right. So -- right. So when I testified earlier, I said that this new theorem that gives us new statistical technique could be applied in any of a number of situations, including biology, chemistry, physics. There are a lot of areas where it could be applied.

So redistricting is not only one potential application of the method, it is literally the application that we use to illustrate the method in our PNAS paper. And at this point, I should say that the Proceedings of the National Academy of Sciences is not a mass-specific journal, so it's not the case that we sent this paper and it was read by some mathematicians who just checked the proof and trusted us on the political science and -- and, you know, the paper got in like that.

So our paper at PNAS was edited by

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somebody who's a demographer and a statistician. It was reviewed by mathematicians and political scientists, and it was accepted both for the mathematics and for our illustration of this potential application. So I think that -- moreover, I would say that not only was the paper accepted in this way, but it's been out for a year; it's been cited already in several political science publications on the subject of gerrymandering; and I know no critiques, published or otherwise, of this application other than the one that has been -- that appeared in the expert testimony that we heard in this trial.

Q. Dr. Cho testified that swapping a single VTD per step wouldn't make large-enough changes to generate a truly new map.

Could you respond to that?

A. Yeah. So -- right. So I can say that this is -- when I first ran my method on Pennsylvania, before I started, I didn't know whether it would work, because I mean, looking at the election results, it seems likely that maybe, you know, just sort of a layperson's analysis might suggest to you that the districting has -- has a Republican bias that's nonrandom, but I wasn't sure

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if the districting was so carefully crafted that you could deduce this from this kind of local outlier analysis.

What's really remarkable is how well it does work. The districting is so carefully crafted to ensure Republican bias that when you make even these smallest moves, the mapmakers would say, No, don't change that; that's exactly how we want it. Every small thing you might change does make the map fairer, and that's the remarkable thing about how carefully crafted this map is.

Q. When you say "fairer," what do you mean?

A. I'm talking about always -- every -- anytime I say "fairer," it's the median-versus-mean metric.

Q. Okay. Dr. Cho also criticized your approach on the grounds that while your algorithm makes two to the 40th steps, you may not have made two to the 40th maps that satisfy the criteria for any given run.

Is that an accurate critique?

A. No. So there are a couple of aspects to this.

So, first, in her report, at least, she

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describes being unclear on exactly how swaps are dealt with; however, in the supplement to our paper, which is -- was submitted with my expert report, we described very precisely what the Markov chain we use is. And, moreover, as we've said before, the code is on my Web site.

So if somehow you found our description ambiguous -- which I, personally, do not believe it is -- you could have checked the details to see exactly what we're doing.

Q. Okay.

A. Okay.

Q. And are you -- and am I right that the -- that the Markov chain -- that each run may not have made exactly two to the 40th unique maps?

A. That's absolutely true. So, remember, the one hypothesis to my theorem is that the Markov chain is reversible; this means that when you're taking the random walk in your city, the streets are all two-way.

So maps are allowed to be repeated, for several different reasons. Sometimes swaps don't succeed. Sometimes swaps are made and then just, by some small chance, reversed. So in this sequence of maps, it is possible, absolutely, that some maps are

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repeated.

As we saw during my cross-examination the other day, it's very easy to tell from my table that an enormous number of distinct maps are actually being created because of the epsilon values in my table.

So that came out. But, absolutely, it is possible the repeated maps are part of this list. That's not only allowed by the hypothesis, my theorem, it's required. And I apply my theorem exactly in this way that I -- that I need to for my results to be precise.

Q. And when you say a large number of maps, as you can see from the epsilon values, do you mean, per run, on the order of hundreds of billions of unique maps?

A. Yes, that's -- that's a reasonable approximation.

Q. Okay.

MR. GEFFEN: Could we look at Petitioners' Exhibit 117, please, which is Dr. Pegden's expert report? And go to Page 4, please, and look at the bullet point at the very top of the page.

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BY MR. GEFFEN:

Q. Do you recall that Dr. Cho was asked for her take on a note in your report about population constraints?

A. Yes.

Q. And she spoke about this bullet point from the top of Page 4?

A. Yes. I recall that she called this "mere conjecture," I think.

Q. What's your response?

A. So I'd like to just give, again, the argument that I give in the bullet point so that I can explain to the Court the simple intuitive -- the simple and intuitive point that I'm making in -- in this part of my report.

So my claim here is that the small population deviation I allow in my comparison maps cannot account for the median/mean gap I observed, okay? And I said -- it was either testimony or cross-examination the other day -- that we -- we see something like a four-point gap in -- in the median-versus-mean scores for the current map and the maps that appear in my test. That means that the median-versus-means metric changes from maybe 6 percentage points to something like 2 percentage

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points. Okay?

Now, suppose that you take one of these comparison maps that I have with a mean/median gap of only 2 percentage points, so appearing more fair than the current map; however, it's just a comparison map and, in particular, it has its allowed population deviation.

Suppose that you wanted to compare -- to modify this map so that it actually followed the legal requirement of having population error of, at most, one person. What would you be required to do?

You would be required to -- to move boundary lines in the districts so that small -- so that small numbers of people, just a few percent in each district, were moved from one district to another.

And remember, my population error that I allow is only 1 percent in some of my runs and 2 percent in the other. Even under a worst-case analysis, this cannot make up the four-point gap that I see in the median-versus-mean test for these maps.

Q. Thank you.

Dr. Cho had some criticisms of your choice of the median/mean difference as a measure of partisan bias.

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If someone wanted to alter your source code to add a new measurement, such as using seats instead of median/mean difference, how hard would it be to do that?

A. In the case of using seats instead of the mean/median gap, you wouldn't even have to alter the code, because at the request of lawyers in the Wisconsin case, I actually implemented this feature in my code for -- for analyzing Wisconsin.

When you download my code and look at the documentation, it literally says, To analyze the districting with respect to seats, type -S, and then it will output the statistics using seats instead of the mean/median test. So you don't even have to modify my code to do this.

I have principled reasons for thinking the mean/median test is a better test to use, but literally -- so it was not hard for me to implement the seat test. And, as it turns out, you don't have to even do it yourself because anybody that's downloaded my code and looked at the documentation knows that it's available right there.

Q. Do you need a -- do you need to sign a confidentiality agreement that we heard discussed today to access that source code and those

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instructions?

A. No. So that's available at a link from my Web site which is advertised in the publication that we've been discussing which appeared in PNAS in January of this year.

Q. And approximately how long has the source code with the option of -- of -S been available on your Web site?

A. That's a good question. I don't recall exactly when I implemented the -S feature, but it's been several months, at least. So a good timeline -- so anybody here that knows when the briefs were filed for the Wisconsin case can get a good estimate. It possibly was in September.

Q. Okay. And does that -S feature work only for Wisconsin, or could you run it on the Pennsylvania map also?

A. No, there's nothing special about Wisconsin in that feature.

Q. Okay. If someone -- is it possible for someone to use your code to evaluate your method or to run a -- a new run like that in -- in -- in -- in less than a week?

A. Absolutely.

So as -- I think I said earlier in my

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testimony the other day that as -- as a mathematician, I really have a strong affinity for precision. I enjoy having a lot of zeros in my table, okay? And to do these trillions of steps, I ran my algorithm for -- for a long time. But my algorithm can generate roughly a million maps in just one second, okay. In a day, you're generating tens of billions of maps.

So just running my algorithm for an hour or a day is enough to not only get excellent statistical significance, which would be acceptable in any field of social science, or even science, that I'm aware of, but would be enough to provide you with literally billions of maps to do an analysis on, to check the robustness with respect to all the things that we've been talking about.

Q. Okay. I'd like to refer you -- turning to a slightly different tape, to just a couple of excerpts from Dr. Cho's testimony from today and ask for your response.

A. Is it actually possible -- I remember there's one more thing I wanted to add to this.

Q. By all means.

A. So just to give an illustration of the sense in which it's not necessary to run for, you

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know, a full week, or that order, to -- to do the analysis, so when you run my algorithm, right, so every second, I claim it's generating millions of maps, okay?

So, remember, we're starting from the current districting in Pennsylvania. And when I say that we observe generally, is that when I make these small changes, over time, we encounter overwhelmingly fair districtings. That is so dramatically the case that after the first second, we never again encourage maps with as much partisan bias as the current districting in Pennsylvania.

Q. Was that true for all eight runs?

A. For all eight runs. Only the first second do you see maps with as much partisan bias as the current map of Pennsylvania. All those rest of the seconds in those 10 days are just for those extra zeros.

Q. Let me refer you to some testimony that Dr. Cho gave earlier today.

At one point, she was asked:

"Question: Okay. Dr. Cho, why isn't this like a question where you would say, If I flip a coin a thousand times, why would I need to

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flip a coin 1,001 times to understand the likelihood of drawing heads on any particular coin flip?"

And the answer:

"Answer: So for a coin, a thousand flips would be perfectly fine. You can understand a lot about a coin with a thousand flips. In fact, you could do extremely well understanding the coin with a thousand flips, and that's because a coin -- the outcome of a flip is either heads or tails, so there are two possible outcomes.

"So you do it a thousand times, you notice whether it's Outcome Number 1 or Outcome Number 2. You would gain very little from tossing a coin one more time than a thousand. But for redistricting, there aren't two outcomes.

"There's -- there's an astronomical number of possible maps with many different outcomes on many

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different facets that someone might be interested in. And so to say I have a thousand maps is completely different from saying I flipped a coin a thousand times, because it's -- it's not even the same thing."

How would you respond to that?

MR. LEWIS: Your Honor, we would object. That testimony was offered not in response to Dr. Pegden but in response to Dr. Chen.

MR. GEFFEN: Dr. Pegden is an expert in probability.

MR. LEWIS: But it's beyond the scope -- it's beyond the scope of his report. And he's being offered -- you know, he's being offered in rebuttal. So I don't know --

MR. GEFFEN: He's an expert who's qualified in probability and who is qualified to opine in response to that.

THE COURT: I'm not sure Dr. Cho's expert report mentioned the coin thing. She brought it up in her testimony. And he's

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being brought up as a rebuttal expert to Dr. Cho.

So I'm going to overrule the objection.

THE WITNESS: Right. So on the face of it -- so I -- I understand the -- the -- the appeal of this idea that maybe there's something simpler about coin flips than very complicated things.

But -- so we talked about this example the other day in testimony where I have some bag of things, I don't know how big it is and I want to know that something is an outlier. And I want to just go through the example again to emphasize that how complex the things are and how -- in addition to how large the bag is does not affect your ability to do this kind of simple rigorous statistics.

So let's imagine for a minute we don't have something simple like coins, we have something very complicated. Like, maybe I have a bag of very complicated, intricate, alien machines. They have all sorts of weird different properties. I

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don't know anything about them. I have no idea how many possible -- how many possibilities there are in my bag.

Okay?

Now, somebody presents me with one machine from this bag, claiming that it's just a typical random member of the bag. And I'm interested in one question about this machine: Is it unusually heavy?

Okay?

This is analogous of the case of redistricting, because districtings, yes, are complicated objects, but when we analyze districtings, we're interested typically in one question about them: Are they unusually partisan?

That's how we're analyzing whether districtings are gerrymandered.

Okay?

And -- so this is the statistical analysis -- so I called this the "Type 2 analysis" the other day in my testimony. I said, Suppose I chose a thousand random samples from this bag of machines and I observed the machine that I was given was

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heavier than all thousand samples I drew from the bag.

Now, I think we can all agree, just thinking about it, that if this machine that I was given to begin with was also a random member of the bag, so all 1,001 machines were actually just random members of the bag, then this machine would have the probability of just one over 1,001 of being the heaviest machine in the bag.

And this analysis, you'll notice the size of the bag doesn't feature into this calculation. I have a 1 and I have a 1,001. There's no size of the bag in the calculation. It doesn't depend -- it doesn't depend on how complicated the machines are. I have this one parameter that I'm interested in, in this case, the weight of the machine, is it -- is it unusually heavy. And I can get a rigorous p-value, in this case, 1 over 1,001, or roughly .001, for the probability that a typical member of the bag would appear to be this unusually heavy.

And I would even tie this back, in

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Dr. Cho's testimony when she was discussing one of the other reports, there was this Number 54 that came up, because 54 was just a terribly small number, but let's imagine doing the same thought experiment drawing 54 machines out of the bag.

So I have my one machine. I draw 54 machines out of the bag. And suppose I know -- suppose I observe that this machine is heavier than all of these 54, so out of the 55, it's the heaviest. If this was really a random member of the bag, that would have probability, at most, 1 over 55; again, a calculation that doesn't depend on how complicated the machines are or how large a bag is.

One over 55 is less than 2 percent. So, I mean, you saw my table. I like numbers smaller than 2 percent, but 2 percent is pretty small.

BY MR. GEFFEN:

Q. Dr. Pegden, based on your analysis, what confidence do you have that the 2011 Pennsylvania Plan was intentionally drawn to maximize partisan advantage?

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A. It is the only explanation I can imagine for having a districting which appears so carefully crafted in the sense of being such an extreme local outlier in the set of its districtings.

MR. GEFFEN: At this point, we'll tender the witness.

THE COURT: For what?

MR. GEFFEN: For any.

THE COURT: Really?

MR. GEFFEN: Well, maybe not.

No?

Sorry. Never mind.

THE COURT: If you would like to tender the witness --

MR. GEFFEN: One moment, please.

THE WITNESS: I like it.

MR. GEFFEN: Sorry.

One more question, and then we're going to excuse our witness.

BY MR. GEFFEN:

Q. Which is, can you -- you just -- you just stated something with some degree of confidence. I wonder if you could quantify for me your degree of confidence in -- in the answer you just gave.

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A. I'm sorry. Which answer was that?

Q. Your --

A. Right, I remember.

Right. So what's great about my table is that it tells you my confidence levels, right? There are these small numbers in this P column. And, in particular, for any column, the problem -- I know that a typical districting of the state would have probability greater than 99.99 percent of passing the test that I employ. So I can quantify, in that respect, the simple way in which I am confident about my findings.

Q. Thank you.

MR. GEFFEN: And, Your Honor, at this point, we would like to excuse the witness.

THE COURT: Well, I just have one question about what you just -- what -- you said a "typical" redistricting.

THE WITNESS: A random -- a random -- so a random member of the bag.

THE COURT: Okay.

THE WITNESS: Yeah.

THE COURT: That's all you meant when you say "typical"?

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THE WITNESS: Yeah, "typical" I just use as a synonym for "random." Yes.
THE COURT: And "fair" you use as a synonym for where it is on the mean/median scale?
THE WITNESS: Exactly, yes.
THE COURT: Okay. Thank you.
THE WITNESS: No problem.
THE COURT: You look like you want to say something, Counsel.
MR. GEFFEN: Sorry.
If I may ask one further question of the witness.
THE WITNESS: We can let you ask one after.
THE COURT: No. No.
Go ahead.
BY MR. GEFFEN:
Q. Dr. --
THE COURT: This is your last one.
BY MR. GEFFEN:
Q. -- Dr. Pegden, can you quantify your degree of confidence that the 2011 Pennsylvania Congressional Plan was intentionally drawn to maximize partisan advantage?

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MR. LEWIS: Your Honor, we object. It goes beyond the scope of any rebuttal. This goes to what -- his direct examination, not to rebuttal.
THE COURT: I would agree with that. I don't think Dr. Cho offered a contrary opinion.
You're asking him to repeat the opinion that he gave in his direct testimony. I don't think she attacked that directly.
So I'm going to sustain the objection.
MR. GEFFEN: Okay. Thank you very much.
THE COURT: That's your last question.
MR. GEFFEN: Yes.
THE COURT: Okay.
Dr. Pegden, thank you very much for your testimony.
THE WITNESS: Okay.
MR. LEWIS: Your Honor, will we have any opportunity to do a recross, since he was recalled.

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THE COURT: Do a recross of what?
MR. LEWIS: Of Dr. Pegden. I mean, he was recalled.
THE COURT: He was recalled in rebuttal. I'm not familiar with the concept of a recross in this context.
Dr. Pegden, you're excused.
THE WITNESS: Okay.
THE COURT: Okay. Do we have any more evidence today, anybody?
MR. JACOBSON: No, Your Honor.
THE COURT: Okay. So we will be in recess till tomorrow morning at 9:30. So let's go off the record.
(Pause.)
THE COURT: We've come back on the record because Legislative Respondents requested permission to cross-examine the rebuttal witness, Dr. Pegden; the Court mistakenly precluded that cross-examination.
So we've recalled Dr. Pegden to the stand, and Legislative Respondents are now able to cross-examine.
So please proceed.
MR. LEWIS: Thank you. Thank you,

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Your Honor. We appreciate it.

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REBUTTAL - CROSS-EXAMINATION

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BY MR. LEWIS:
Q. Dr. Pegden, your paper was published in the Proceedings of the National Academy of Sciences on March 14th of 2017; is that correct?
A. Let me check.
How do I find this?
Q. Here's what I can do: We can -- we'll use the Elmo. I feel like we should.
It's Petitioners' Exhibit 119, if you want to look in your binder.
THE COURT: Volume 2.
THE WITNESS: Okay. Thanks.
BY MR. LEWIS:
Q. Volume 2.
A. 119.
So -- yes, so March 14th is, like, the print edition date. This is not actually the first date when this appeared online.
So that's a little bit misleading.
So I think it was close to the

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beginning of the year when -- when it first appeared online. But, actually, I can't tell the date from this (indicating).

I would also say, in case it's helpful, that a preprint of the paper, which was essentially identical to the form which was finally published, was online at the Archive.org repository, a standard repository for scientific papers, even in 2016.

But, yeah, so this -- I believe that this March 14th date that you see on the bottom is not when this was first available from PNAS. That's my understanding. I really hope I'm not getting that wrong.

Q. Okay. That's not a whole lot of time for someone to -- to -- reading the article to really read, review, test, write and publish a criticism, is it?

A. Oh, I really disagree with that. I mean, I've received contact from people who did exactly that, that downloaded my code, that had questions about how I did things.

Remember, I provide -- you don't have to somehow redo everything I do, because I provide the code and instructions on how to use it. The proof of the theorem, although it's an important

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breakthrough in statistics, is, in some sense, not that complicated, so it's not that hard to engage with what I did in a full and complete way in a very short amount of time.

So there's somebody else at Carnegie Mellon that -- you know, who I didn't know who saw this paper and was very interested in it, and when it came out, I mean, he very quickly -- so he's not a mathematician but still checked the proof in a relatively short period of time. He downloaded my code and was using it. He had questions about how to -- how to use it. And I would say that all of my interactions with him, you know, the major portion of them happened in a span of just a few weeks.

Q. Okay. Dr. Pegden, returning -- and I won't -- if you want me to put the figure back up, I will, but I think we've seen it with the Figure 1 from -- from your article.

I'll just put it up. We'll put it on Elmo, or not.

There we go.

With the green dot surrounded by the pink dots.

The -- the significance -- the statistical significance of your -- of your Markov

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chain runs with respect to the question of is the green dot unlike the pink dots.

Doesn't the validity of that analysis turn on whether the bag of districtings, in other words, whether the pink dots around the green dot, you know, are a reasonable sample or a reasonable -- I should say reasonable criteria to use to measure the question that you were attempting to address?

A. Can you try rephrasing the question?

Q. Yeah. That question made no sense. I apologize.

So if -- the purpose of this, as I understand it, is you're trying to tell if the green dot is unlike the pink dots, right? That's --

A. Yeah, that's a nice analogy -- not even on the pink dots. So the correct analogy here is the green dot that we see here (indicating) that's surrounded by pink dots, unusual, among the whole universe of dots, which we don't even see.

I mean, somehow the green dot is obviously different from the pink dots. It's green, and they're pink. We're asking a different question.

Q. Okay. Got it.

So the significance of your -- of your findings, does it not depend -- for purposes of

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redistricting, does it not depend on the choices that you make for what comparison districtings you include in your bag of districtings?

A. Yes, so it's absolutely the case that, you know, when I apply my method to redistricting, I try to choose reasonable constraints on the districtings, like compactness, contiguity of districtings, reasonable population constraints, and I think that the way I choose those constraints does have bearing on my application. Yes.

MR. LEWIS: Your Honor, we have nothing further.

THE COURT: Redirect?

MR. GEFFEN: Nothing further, Your Honor.

THE COURT: Okay. Now you can step down.

THE WITNESS: Okay.

THE COURT: Thank you.

THE WITNESS: I'll put this (indicating) back quickly.

THE COURT: Okay.

THE WITNESS: That's my last act.

THE COURT: Petitioners, anything further today?

MR. GEFFEN: No, Your Honor.
THE COURT: Respondents?
MR. FREEDMAN: No, Your Honor.
THE COURT: We stand in recess until 9:30 tomorrow morning.
THE CLERK: The Commonwealth Court is now in recess.

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(Whereupon, the trial adjourned at 6:14 p.m., to reconvene on Friday, December 15, 2017, at 9:30 a.m.)

COMMONWEALTH OF PENNSYLVANIA:

I, Cindy L. Sebo, a court reporter within and for the Jurisdiction aforesaid, do hereby certify that the foregoing proceeding were pursuant to notice, at the time and place indicated; that the testimony of said was correctly recorded in machine shorthand by me and thereafter transcribed under my supervision with computer-aided transcription; that the proceedings are true record of the testimony given; and that I am neither of counsel nor kin to any party in said action, nor interested in the outcome thereof.

Cindy L. Sebo, RMR, CRR, RPR, CSR,
CCR, CLR, RSA, LiveDeposition
Authorized Reporter, and Notary Public