



Planet Depos®
We Make It *Happen™*

Transcript of Deborah Fuller, Ph.D.

Date: August 2, 2024

Case: BioNTech SE and Pfizer, Inc. -v- Moderna TX, Inc. (PTAB)

Planet Depos

Phone: 888.433.3767

Email: transcripts@planetdepos.com

www.planetdepos.com

WORLDWIDE COURT REPORTING & LITIGATION TECHNOLOGY

Transcript of Deborah Fuller, Ph.D.
Conducted on August 2, 2024

1 (1 to 4)

<p>1 UNITED STATES PATENT AND TRADEMARK OFFICE</p> <p>2 -----</p> <p>3 BEFORE THE PATENT TRIAL AND APPEAL BOARD</p> <p>4 -----</p> <p>5 BIONTECH SE AND PFIZER INC.</p> <p>6 Petitioner</p> <p>7 v.</p> <p>8 MODERNATX, INC.</p> <p>9 Patent Owner</p> <p>10 -----</p> <p>11 Case IPR2023-01358</p> <p>12 Patent 10,702,600</p> <p>13 and</p> <p>14 Case IPR2023-01359</p> <p>15 Patent 10,933,127</p> <p>16 -----</p> <p>17 Deposition of</p> <p>18 DEBORAH FULLER, PH.D.</p> <p>19 Boston, Massachusetts</p> <p>20 Friday, August 2, 2024</p> <p>21 9:07 a.m.</p> <p>22 Job No.: 547017</p> <p>23 Pages: 1 - 277</p> <p>24 Reported By: Michelle Keegan, RMR, CRR, CSR</p>	<p>3</p> <p>1 A P P E A R A N C E S</p> <p>2</p> <p>3 ON BEHALF OF PETITIONER</p> <p>4 BIONTECH SE AND PFIZER INC.:</p> <p>5 ASHLEY N. MAYS-WILLIAMS, ESQ.</p> <p>6 RYAN MEUTH, ESQ.</p> <p>7 PAUL HASTINGS LLP</p> <p>8 200 Park Avenue</p> <p>9 New York, New York 10166</p> <p>10 (212) 318-6000</p> <p>11</p> <p>12 ON BEHALF OF PETITIONER PFIZER INC.:</p> <p>13 DAVID M. KRINSKY, ESQ.</p> <p>14 MICHAEL XUN LIU, ESQ.</p> <p>15 WILLIAMS & CONNOLLY LLP</p> <p>16 680 Main Avenue SW</p> <p>17 Washington, DC 20024</p> <p>18 (202) 434-5000</p> <p>19</p> <p>20</p> <p>21</p> <p>22</p>
<p>2</p> <p>1 Deposition of DEBORAH FULLER, PH.D.,</p> <p>2 held at the offices of:</p> <p>3</p> <p>4 WILMER CUTLER PICKERING HALE AND DORR LLP</p> <p>5 60 State Street</p> <p>6 Boston, Massachusetts 02109</p> <p>7 (617) 526-6000</p> <p>8</p> <p>9</p> <p>10</p> <p>11 Pursuant to notice, before Michelle</p> <p>12 Keegan, Registered Merit Reporter and Notary</p> <p>13 Public in and for the Commonwealth of</p> <p>14 Massachusetts.</p> <p>15</p> <p>16</p> <p>17</p> <p>18</p> <p>19</p> <p>20</p> <p>21</p> <p>22</p>	<p>4</p> <p>1 APPEARANCES (continued):</p> <p>2</p> <p>3 ON BEHALF OF PATENT OWNER MODERNATX, INC.:</p> <p>4 KEVIN S. PRUSSIA, ESQ.</p> <p>5 CLAIRE M. SPECHT, ESQ.</p> <p>6 WILMER CUTLER PICKERING HALE AND DORR LLP</p> <p>7 60 State Street</p> <p>8 Boston, Massachusetts 02109</p> <p>9 (617) 526-6243</p> <p>10</p> <p>11 ALSO PRESENT:</p> <p>12 Vinny Lee, BioNTech</p> <p>13 Jacob Moore, Moderna</p> <p>14</p> <p>15</p> <p>16</p> <p>17</p> <p>18</p> <p>19</p> <p>20</p> <p>21</p> <p>22</p>

Transcript of Deborah Fuller, Ph.D.
Conducted on August 2, 2024

2 (5 to 8)

5	7
1 C O N T E N T S	1 P R O C E E D I N G S
2	2 DEBORAH FULLER, PH.D.,
3 EXAMINATION OF DEBORAH FULLER, PH.D. PAGE	3 having been satisfactorily identified and duly
4 By Ms. Mays-Williams 7	4 sworn by the Notary Public, was examined and
5 By Mr. Prussia 254	5 testified as follows:
6	6 EXAMINATION BY COUNSEL FOR
7 E X H I B I T S	7 PETITIONER BIONTECH SE and PFIZER INC.
8 (Attached to transcript.)	8 BY MS. MAYS-WILLIAMS:
9 FULLER DEPOSITION EXHIBITS PAGE	9 Q. Good morning, Dr. Fuller.
10 Exhibit 1098 Curriculum Vitae Deborah Fuller 18	10 A. Good morning.
11 Exhibit 1099 Article, "An Alphavirus-derived 35	11 Q. Could you please state your full name for
12 replicon RNA vaccine induces	12 the record.
13 SARS-CoV-2 neutralizing	13 A. My full name is Deborah Lynne Fuller.
14 antibody and T cell responses	14 Q. Can you please state your home address?
15 in mice and nonhuman primates"	15 A. 9450 Northeast Coral Court, Bainbridge
16 Exhibit 1100 Article, "How mRNA and DNA 75	16 Island, Washington.
17 vaccines could soon treat	17 Q. Where are you currently employed?
18 cancers, HIV, autoimmune	18 A. I'm currently employed at the University
19 disorders and genetic diseases"	19 of Washington.
20 Exhibit 1101 Article, "Evaluation of 142	20 Q. And what's your current title?
21 candidate vaccine approaches	21 A. My current title is a professor in the
22 for MERS-CoV"	22 department of microbiology. I'm also the interim
6	8
1 PREVIOUSLY MARKED EXHIBITS	1 director of the Washington National Primate
2 (Not attached to transcript.)	2 Research Center.
3 Exhibit 1001 ['127]..... 122	3 Q. Have you been deposed before?
4 Exhibit 1001 ['600]..... 122	4 A. No.
5 Exhibit 1009 209	5 Q. And have you ever testified at trial?
6 Exhibit 1010 239	6 A. I have never.
7 Exhibit 1022 88	7 Q. Okay. At the beginning of the deposition,
8 Exhibit 1031 70	8 you just took an oath. Correct?
9 Exhibit 2021 102	9 A. Correct.
10 Exhibit 2027 198	10 Q. And do you intend to answer my questions
11	11 fully and to the best of your ability today?
12	12 A. I do.
13 ** Documents quoted on the record are transcribed	13 Q. Is there anything affecting your ability
14 as read **	14 to testify fully and truthfully today?
15	15 A. No.
16	16 Q. I see that you've brought some materials
17	17 in with you. What do you have there?
18	18 A. I have my declaration for the '127 and
19	19 '600.
20	20 Q. And does your declaration contain any
21	21 annotations or notes whatsoever?
22	22 A. None.

Conducted on August 2, 2024

<p>9</p> <p>1 Q. And are you being compensated for your</p> <p>2 testimony today?</p> <p>3 A. I'm being compensated for my time. Yes.</p> <p>4 Q. And how much?</p> <p>5 A. \$320 an hour.</p> <p>6 Q. Okay. Before we turn to the substance, I</p> <p>7 want to just go over some administrative details</p> <p>8 for our conversation today.</p> <p>9 I'm going to ask you a series of</p> <p>10 questions, and you are obligated to fully answer</p> <p>11 the question that I have asked, even if there are</p> <p>12 objections raised, unless your counsel instructs</p> <p>13 you not to answer. Okay?</p> <p>14 A. Uh-hmm.</p> <p>15 Q. We'll take a break approximately every</p> <p>16 hour, every hour, but if you need to take a break</p> <p>17 sooner than that then you can ask for one. I'll</p> <p>18 just ask if there is a question pending, that you</p> <p>19 answer that question before the break is taken.</p> <p>20 Is that okay?</p> <p>21 A. That's okay.</p> <p>22 Q. And we have a court reporter here that's</p>	<p>11</p> <p>1 A. That's right.</p> <p>2 Q. And do you understand that IPR2023-1358</p> <p>3 involves U.S. Patent Number 10,702,600?</p> <p>4 A. Yes.</p> <p>5 Q. Will you understand if I refer to that</p> <p>6 throughout today as "the '600 patent"?</p> <p>7 A. I will. Yeah.</p> <p>8 Q. And you understand that IPR2023-1359</p> <p>9 involves U.S. Patent Number 10,933,127?</p> <p>10 A. Right. That's right.</p> <p>11 Q. And will you understand if I refer to that</p> <p>12 throughout today as "the '127 patent"?</p> <p>13 A. I will.</p> <p>14 Q. And you've submitted a declaration in each</p> <p>15 of the proceedings on behalf of the patent owner,</p> <p>16 Moderna. Correct?</p> <p>17 A. Right. Two declarations.</p> <p>18 Q. And those two declarations are titled</p> <p>19 "Declaration of Deborah Fuller" in both instances?</p> <p>20 A. They are.</p> <p>21 Q. And your declaration has been marked as</p> <p>22 Exhibit 2199 in the 1359 proceeding. Is that</p>
<p>10</p> <p>1 transcribing our conversation. And because of</p> <p>2 that, it's important that you give me verbal</p> <p>3 answers to the questions instead of nods of the</p> <p>4 head and things like that. Is that okay?</p> <p>5 A. That's okay.</p> <p>6 Q. And it's also not possible for the court</p> <p>7 reporter to transcribe two people talking at once,</p> <p>8 so I'll do my very best not to talk over you and</p> <p>9 I'll ask you to do the same. Is that okay?</p> <p>10 A. Okay.</p> <p>11 Q. And if you don't understand any of my</p> <p>12 questions, please do let me know.</p> <p>13 A. Okay.</p> <p>14 Q. If you answer the question, I'll assume</p> <p>15 that you understood it. Is that fair?</p> <p>16 A. That's fair.</p> <p>17 Q. Now, you understand that you're here to</p> <p>18 testify in two proceedings before the U.S. Patent</p> <p>19 Trial and Appeal Board. Correct?</p> <p>20 A. Correct.</p> <p>21 Q. And the two proceedings are IPR2023-1358</p> <p>22 and IPR2023-1359. Is that right?</p>	<p>12</p> <p>1 right?</p> <p>2 A. That's right.</p> <p>3 Q. And Exhibit 2195 in the 1358 proceeding.</p> <p>4 Right?</p> <p>5 A. It says "2199" in both cases on the cover.</p> <p>6 Q. 2199.</p> <p>7 When were you first contacted by counsel</p> <p>8 for Moderna?</p> <p>9 A. Let's see. I was contacted, it would have</p> <p>10 been in 2021.</p> <p>11 Q. When in 2021?</p> <p>12 A. I'm trying to remember. It would have</p> <p>13 been late -- mid to late fall of 2021.</p> <p>14 Q. Who contacted you?</p> <p>15 A. I do not recall the name.</p> <p>16 Q. Do you recall whether it was Kevin</p> <p>17 Prussia?</p> <p>18 A. It was not Kevin Prussia.</p> <p>19 Q. Do you recall whether it was Claire?</p> <p>20 A. It was not Claire.</p> <p>21 Q. Were you aware of the '600 or the '127</p> <p>22 patents before you began consulting with Moderna?</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 4 of 130

Conducted on August 2, 2024

<p>13</p> <p>1 A. I was not.</p> <p>2 Q. You're also presently consulting with</p> <p>3 Pfizer. Correct?</p> <p>4 A. I have been consulting with them on their</p> <p>5 influenza vaccine program.</p> <p>6 Q. Influenza vaccine program?</p> <p>7 A. Uh-hmm.</p> <p>8 Q. And what does the consultancy involve?</p> <p>9 A. Well, to date, we haven't met. We had set</p> <p>10 up a meeting and then I got an email, something</p> <p>11 has come up and they're going to postpone. So I</p> <p>12 have not actually met as a consultant for them.</p> <p>13 Q. When did that consultancy begin?</p> <p>14 A. That was in -- let me see when I . . .</p> <p>15 That would have been in 2023, early 2023.</p> <p>16 They reached out to me whether I'd be willing to</p> <p>17 serve on an advisory board, scientific advisory</p> <p>18 board for the influenza vaccine program.</p> <p>19 Q. So you were asked to be on the scientific</p> <p>20 advisory board of Pfizer?</p> <p>21 A. Yes. They call it SAB.</p> <p>22 Q. What did you do to prepare for your</p>	<p>15</p> <p>1 declaration.</p> <p>2 Q. Did you review anything that wasn't cited</p> <p>3 in your declaration in preparation for your</p> <p>4 deposition today?</p> <p>5 A. Yes, I did review other things.</p> <p>6 Q. What else did you review?</p> <p>7 A. Just contemporary literature related to</p> <p>8 the subject.</p> <p>9 Q. And what was that contemporary literature?</p> <p>10 A. That would be, like, what is, for example,</p> <p>11 the latest coronavirus variants currently</p> <p>12 circulating.</p> <p>13 Q. Anything else?</p> <p>14 A. I looked up that this morning.</p> <p>15 I reviewed a review on mRNA vaccines,</p> <p>16 which actually I think was one of the things cited</p> <p>17 in my declaration.</p> <p>18 Q. Anything else?</p> <p>19 A. There were other things, but I can't</p> <p>20 specify.</p> <p>21 Just, in general, as a scientist, I'm</p> <p>22 constantly reviewing literature related to my</p>
<p>14</p> <p>1 deposition today?</p> <p>2 A. So for preparation, I read the materials</p> <p>3 associated with my declaration. I reread my</p> <p>4 declaration. I met with the attorneys.</p> <p>5 Q. Who did you meet with?</p> <p>6 A. I've met with everyone in this room, Kevin</p> <p>7 and Claire and Jake as well as Anastasia</p> <p>8 Greenberg.</p> <p>9 Q. Kevin, Claire, Jake and Anastasia, you</p> <p>10 said?</p> <p>11 A. Yes.</p> <p>12 Q. Anyone else?</p> <p>13 A. There were -- some came and went, but I</p> <p>14 don't recall their names.</p> <p>15 Q. Do you know if everyone you met was an</p> <p>16 attorney?</p> <p>17 A. Yes.</p> <p>18 Q. You said you reviewed your declaration.</p> <p>19 Correct?</p> <p>20 A. Yes.</p> <p>21 Q. What other materials did you review?</p> <p>22 A. Materials related to and cited by the</p>	<p>16</p> <p>1 field, which in turn is also related to this. So</p> <p>2 I had that in mind.</p> <p>3 Q. You mentioned mRNA vaccine review.</p> <p>4 A. Yeah.</p> <p>5 Q. Do you recall that with some specificity?</p> <p>6 A. In terms of which one?</p> <p>7 Q. You mentioned the mRNA vaccine.</p> <p>8 A. Yeah.</p> <p>9 Q. Which mRNA vaccine review are you</p> <p>10 referring to?</p> <p>11 A. Let me see if I can remember what the</p> <p>12 title was.</p> <p>13 I don't remember the title.</p> <p>14 Q. Do you remember the authors?</p> <p>15 A. No.</p> <p>16 Q. Do you remember the year?</p> <p>17 A. 2020. 2020, I believe.</p> <p>18 Q. Do you remember anything else that you</p> <p>19 reviewed in terms of contemporary literature that</p> <p>20 you view as related to your declaration in</p> <p>21 preparation for your deposition?</p> <p>22 A. No, I don't really remember.</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 5 of 130

Conducted on August 2, 2024

<p>17</p> <p>1 Q. You mentioned that you met with your 2 attorneys to prepare for the deposition? 3 A. Yes. Uh-hmm. 4 Q. When did you meet with them? 5 A. I met with them for -- I came in on 6 Tuesday night, so I met with them on Wednesday and 7 Thursday. 8 Q. For how long did you meet with them? 9 A. A full business day. 10 Q. A full business day on Wednesday and a 11 full business day on Thursday? 12 A. Correct. Yeah. 13 Q. You met with no one else? 14 A. Other than the people I specified. 15 Correct. 16 Q. When were you first put in contact with 17 Kevin? 18 A. That would have been -- first time I met 19 Kevin was -- I'm just trying to remember when that 20 was. That was in 2022 or 2023. I don't remember. 21 Q. And Claire? 22 A. And Claire, I think that was in 2022, but</p>	<p>19</p> <p>1 the Washington National Primate Research Center. 2 That just came up at the -- in June. 3 Q. Did you draft this page, Dr. Fuller? 4 A. I did. 5 Q. Let's take a look at some of the language 6 that you've included here. 7 Under the heading "Current Research," your 8 website reads, "Similarly, the worldwide 9 variability of influenza and SARS-CoV-2 makes it 10 difficult to predict which viral strain might 11 acquire the ability to infect the human 12 population, and due to the narrow timeframe 13 between detecting human infection and" . . . 14 "predict" -- "and produce" method for 15 generating the vaccine each season, current 16 influenza and coronavirus vaccines will likely be 17 inadequate for preventing the next pandemic." Do 18 you see that? 19 A. That's what it says. Yes. 20 Q. What does it mean that the "current 21 influenza and coronavirus vaccines will likely be 22 inadequate for preventing the next pandemic"?</p>
<p>18</p> <p>1 I don't recall. 2 (Fuller Exhibit 1098 was marked for 3 identification and is attached to the transcript.) 4 Q. The court reporter has marked or handed 5 you what's been marked as Exhibit 1098. 6 Have you seen this before? 7 A. This looks like it comes off the UW 8 Microbiology website. 9 Q. So it's fair to say that this is a 10 printout of your page at the University of 11 Washington website. Fair? 12 A. I'm just reading it to make sure it's the 13 latest version. 14 Q. Okay. 15 A. It needs to be updated, but it looks like 16 it's the most recent version on the website. 17 Q. How does it need to be updated? 18 A. I've expanded my research into fungal 19 diseases now. That's not listed there. 20 Q. Does it need to be updated in any other 21 way other than mentioning the fungal diseases? 22 A. I'm actually now the interim director at</p>	<p>20</p> <p>1 A. That means that should we have a new 2 pandemic -- we do have influenza and coronavirus 3 vaccines that provide protection against current 4 circulating strains. 5 A new pandemic would mean a new viral 6 variant has emerged that is able -- that is 7 different from the current variants that are 8 circulating. 9 And so most are -- both our current 10 influenza and coronavirus vaccines are designed to 11 match those current circulating strains. 12 So a new variant would be able to dodge 13 the immunity generated by those vaccines. That 14 doesn't mean those vaccines will be completely 15 ineffective. It just means they won't be as 16 effective as if they were a precise match to that 17 strain. 18 Q. So there are currently approved vaccines 19 against coronavirus and SARS-CoV-2? 20 A. Yes. 21 Q. And the current vaccines against 22 SARS-CoV-2 are not necessarily adequate for</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 6 of 130

Conducted on August 2, 2024

<p style="text-align: right;">21</p> <p>1 preventing human infection by a future coronavirus 2 that has not yet emerged. Is that fair? 3 A. It depends on what the future variant 4 looks like. 5 Q. It's not easy to predict whether the 6 current SARS-CoV-2 vaccines would be adequate for 7 preventing human infection. Is that fair? 8 A. It depends on the coronavirus variant that 9 would emerge. The current coronavirus vaccines 10 are designed to protect against the 11 betacoronaviruses. There are other coronaviruses 12 out there besides betacoronaviruses that can 13 potentially transmit to humans. 14 Q. Is it fair to say that scientists would 15 have to develop a novel vaccine to protect against 16 human infection by future betacoronaviruses that 17 have not yet been identified? 18 A. So define "novel." 19 Q. A betacoronavirus that has not yet been 20 identified. 21 A. So when we talk about vaccines in terms of 22 novelty for a vaccinologist, what I think of as a</p>	<p style="text-align: right;">23</p> <p>1 Q. Any preexisting vaccine against MERS 2 proved inadequate to protect against infection by 3 SARS-CoV-2. Right? 4 A. So that would be correct that the MERS 5 vaccine would not protect against the SARS-CoV-2 6 vaccine. It would need to be updated to match 7 whatever would be the SARS-CoV-2 sequence. 8 Q. Let's go back to your page for a moment. 9 About ten lines from the bottom, your page 10 states, "Similarly, using DNA and RNA vaccines and 11 antivirals designed to precisely target highly 12 conserved regions in influenza, we have shown 13 significant protection against a wide range of 14 strains in mice and nonhuman primates." Right? 15 A. That's right. 16 Q. And when did this work occur that you're 17 referring to here? 18 A. This work is ongoing. 19 Q. When did it begin? 20 A. This work began five years ago. 21 Q. Why did you group DNA and RNA vaccines 22 together here in this section of your page?</p>
<p style="text-align: right;">22</p> <p>1 novel vaccine would entail an entirely novel 2 platform that doesn't exist today. 3 So when I talk about an updated vaccine, 4 for example if we had an influenza pandemic, you 5 could update our current influenza vaccines to 6 match the new pandemic, but they wouldn't be 7 adequate because they take too long to manufacture 8 and produce to be able to stop an emerging 9 pandemic. 10 Likewise, with the current mRNA vaccines 11 for SARS-CoV-2, if you had a new betacoronavirus 12 emerge in which the current vaccines are not a 13 good match or providing sufficient protection, 14 that mRNA vaccine could be updated by simply 15 swapping out the sequence for the spike protein 16 encoded by the mRNA vaccine with the one that 17 matches whatever is circulating or the emerging 18 threat. 19 Q. Scientists had vaccines against MERS-CoV 20 at the time that the COVID-19 pandemic emerged. 21 Correct? 22 A. There were no licensed vaccines for MERS.</p>	<p style="text-align: right;">24</p> <p>1 A. So my expertise is primarily in nucleic 2 acid vaccines. So that includes both DNA as well 3 as RNA vaccines, including self-amplifying RNA as 4 well as mRNA vaccines. 5 Q. Both nucleic acid vaccines. Correct? 6 A. All DNA and RNA vaccines are classified 7 under the same grouping of nucleic acid vaccines, 8 but they are distinct modalities. DNA and RNA 9 vaccines are different. 10 Q. What type of RNA did the vaccines use that 11 you're referring to here? 12 A. Which vaccine? 13 Q. You mentioned DNA and RNA vaccines in this 14 sentence that we just discussed. Right? 15 A. Uh-hmm. 16 Q. What type of RNA did the vaccines that 17 you're referring to there use? 18 A. Could you point to the sentence again? 19 Q. My apologies. It says, "Similarly, using 20 DNA and RNA vaccines." Do you see that there? 21 A. Correct. 22 Q. What are you referring to there in terms</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 7 of 130

Conducted on August 2, 2024

<p>25</p> <p>1 of the type of RNA that's being used?</p> <p>2 A. So the type of RNA vaccines that I'm using</p> <p>3 are both -- we have designed the immunogen.</p> <p>4 And so the platforms or the cassettes are</p> <p>5 either self-amplifying RNA or mRNA. We insert</p> <p>6 them into self-amplifying mRNA and insert them</p> <p>7 into mRNA, as well as DNA, and then we compare all</p> <p>8 three different modalities together to determine</p> <p>9 which of the three modalities might provide us</p> <p>10 with the immunogenic profile we're looking for, as</p> <p>11 well as the efficacy, because each of those</p> <p>12 platforms we're learning result in very different</p> <p>13 types of immune responses and can perform</p> <p>14 differently depending on the type of immunogen</p> <p>15 that you insert into them.</p> <p>16 Q. What influenza antigens did these DNA and</p> <p>17 RNA vaccines encode?</p> <p>18 A. Could you repeat the question?</p> <p>19 Q. Yes. What influenza antigens did these</p> <p>20 DNA and RNA vaccines encode?</p> <p>21 A. Well, I'm actually -- that's kind of</p> <p>22 proprietary information. It's part of a patent</p>	<p>27</p> <p>1 A. Identical sequences.</p> <p>2 Q. And why did you choose identical sequences</p> <p>3 for those DNA and RNA vaccines?</p> <p>4 A. So the objective of the experiments that</p> <p>5 we're doing is, we have designed an immunogen that</p> <p>6 is, you know, based on sequences that have been</p> <p>7 identified to correspond with epitopes associated</p> <p>8 with improved control of those viruses. And so we</p> <p>9 designed a single immunogen.</p> <p>10 And the question that we're now asking is</p> <p>11 which of those platforms -- mRNA, self-amplifying</p> <p>12 RNA, or DNA -- would be the best one to express</p> <p>13 those antigens and induce the -- a broad immune</p> <p>14 response.</p> <p>15 Q. Is it fair to say that the antigen</p> <p>16 selection would apply equally to DNA and RNA</p> <p>17 vaccines? Is that fair?</p> <p>18 A. No, that's not what I'm saying.</p> <p>19 I'm actually saying that our hypothesis is</p> <p>20 that those three platforms are likely to perform</p> <p>21 differently even when you insert the same antigen</p> <p>22 in them.</p>
<p>26</p> <p>1 application I have going on.</p> <p>2 Q. Did they encode the same influenza</p> <p>3 antigens?</p> <p>4 A. So when I actually test them in the three</p> <p>5 different platforms, they will encode identical</p> <p>6 immunogens. Yes.</p> <p>7 Q. How did you decide which influenza</p> <p>8 antigens to encode in the DNA and RNA vaccines?</p> <p>9 A. So it was a number of years of study to</p> <p>10 determine the different types of immunogens</p> <p>11 that -- what we're targeting here is defining</p> <p>12 those actions of what we would call a</p> <p>13 theoretically universal vaccine.</p> <p>14 And so that would be one that would be</p> <p>15 designed to induce immune responses primarily</p> <p>16 targeting highly conserved regions.</p> <p>17 My lab is really interested in a</p> <p>18 hypothesis focused on a significant role for</p> <p>19 T-cell responses in providing cross-protection, as</p> <p>20 well as inducing mucosal immune responses.</p> <p>21 Q. You mentioned a moment ago that the DNA</p> <p>22 and RNA vaccines encode identical antigens.</p>	<p>28</p> <p>1 Q. That you decided to choose identical</p> <p>2 influenza antigens. Right?</p> <p>3 A. That's how you would do that experiment.</p> <p>4 If you want to test the hypothesis that</p> <p>5 each of those platforms will perform differently,</p> <p>6 then you have to hold all other variations --</p> <p>7 variables constant. And that includes the antigen</p> <p>8 that you insert into them.</p> <p>9 Q. What do you mean when you say the</p> <p>10 platforms will perform differently?</p> <p>11 A. I mean DNA, mRNA, or self-amplifying RNA.</p> <p>12 Q. Can you explain that?</p> <p>13 A. So when I refer to a vaccine platform,</p> <p>14 what I'm referring to is a type of modality, call</p> <p>15 it a modality or platform, that you can use</p> <p>16 theoretically for a variety of different</p> <p>17 infectious diseases.</p> <p>18 So for example, I often have used in the</p> <p>19 past a modified vaccine -- Ankara is a viral</p> <p>20 vector. That's one platform.</p> <p>21 Messenger RNA is another platform where</p> <p>22 you can insert different sequences. All the other</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 8 of 130

Conducted on August 2, 2024

<p>29</p> <p>1 elements stay the same. You just swap out 2 whatever is a sequence for the antigen. 3 DNA is another platform. Same thing. And 4 self-amplifying RNA is another platform. 5 Q. So you didn't choose a different antigen 6 based on whether you were working with a DNA or 7 RNA vaccine. Right? 8 A. I'm not sure I understand your question. 9 Q. You already said that you chose the same 10 identical antigen for the DNA- and RNA-based 11 vaccines. Right? 12 A. So the purpose of the study was to 13 determine which of the two platforms is going to 14 provide the types of immune responses we want to 15 induce and the best protection in the animal 16 models that we're studying. 17 Q. Let me ask it a little bit differently. 18 Is it fair to say that you would seek to 19 target the same influenza antigen irrespective of 20 whether it's a DNA-based vaccine or an RNA-based 21 vaccine? 22 A. Well, it depends on what the experiments</p>	<p>31</p> <p>1 A. Correct. 2 Q. And again, you've grouped DNA and RNA 3 vaccines here. Right? 4 A. Correct. 5 Q. And why have you done that? 6 A. Because I was working on both at the same 7 time. 8 Q. And how did you decide which COVID-19 9 antigens to encode in the DNA and RNA vaccines? 10 A. So in that -- what we're referring to here 11 are some studies that we started on January 7th 12 of 2020 when the sequence for the circulating 13 SARS-CoV-2 variant was published, first published. 14 And so like any other researcher, we just used 15 that sequence. 16 Q. And what antigen did the DNA-based vaccine 17 encode? 18 A. So for both the DNA and the RNA vaccine, 19 we encoded the spike protein. 20 Q. The same antigen. Right? 21 A. Correct. 22 Q. Your web page doesn't call out any</p>
<p>30</p> <p>1 show. 2 For example, if I find that an mRNA 3 vaccine is superior for inducing antibody and the 4 DNA vaccine platform doesn't induce as good an 5 antibody but better T-cell responses, then I might 6 have a situation where I would look at that and 7 say, well, maybe I want to encode the component 8 that I really want to induce antibodies for and 9 use mRNA or self-amplifying RNA, whatever, for 10 that. And maybe I want to use a DNA platform to 11 encode the T-cell component. 12 Q. Would you seek to target the same highly 13 conserved regions in influenza as an antigen 14 irrespective of whether you go with a DNA vaccine 15 or an RNA vaccine? 16 A. Again, it depends on the data. I'd have 17 to see what the data presents from it. 18 Q. Let's go back to your web page. 19 It says, "More recently, we have shown 20 that DNA and RNA vaccines can be rapidly developed 21 in response to an emerging pandemic such as 22 COVID-19." Correct?</p>	<p>32</p> <p>1 experience with mRNA vaccines, does it? 2 A. With mRNA specifically, no. 3 Q. And as of October 2015, what was your 4 experience with mRNA vaccines? 5 A. October 2015? 6 Q. Correct. 7 A. So I had started nucleic acid vaccine 8 research in 1990 using different technologies, 9 developing technology for delivery. 10 In the early 1990s, the field of nucleic 11 acid vaccines was new, had not really been 12 discovered. It really had kind of come to 13 fruition in 1992. 14 So when we think about nucleic acid 15 delivery, we were looking at DNA, we were looking 16 at mRNA at the time. We were not looking at 17 self-amplifying RNA in the early 1990s. 18 So between 1990 and 1998, I did 19 experiments with both DNA and mRNA. mRNA 20 consistently failed in those experiments, but DNA 21 was successful. And for the next two decades 22 after that, my primary focus was on DNA.</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

Conducted on August 2, 2024

<p>33</p> <p>1 And then in 2019, I started working with</p> <p>2 self-amplifying RNA.</p> <p>3 Q. What do you mean when you said mRNA</p> <p>4 consistently failed in those experiments between</p> <p>5 1990 and 1998?</p> <p>6 A. When we compared head-to-head a DNA</p> <p>7 vaccine expressing a given immunogen and an mRNA</p> <p>8 that we'd make an mRNA transcript off of the DNA</p> <p>9 expressing the same immunogen, we compared them</p> <p>10 head-to-head using our different delivery</p> <p>11 platforms or strategies.</p> <p>12 The DNA vaccine would induce an immune</p> <p>13 response and the mRNA vaccine would fail.</p> <p>14 Q. Was that due to lack of mRNA stability?</p> <p>15 A. When we analyzed the vaccines after we had</p> <p>16 immunized the mice, we saw that there was quite a</p> <p>17 bit of degradation of the mRNA and concluded that</p> <p>18 was probably one of the reasons why the mRNA</p> <p>19 vaccine was not working as well as the DNA</p> <p>20 vaccine.</p> <p>21 Q. You mentioned different delivery</p> <p>22 strategies that you used for DNA vaccines and mRNA</p>	<p>35</p> <p>1 (Fuller Exhibit 1099 was marked for</p> <p>2 identification and is attached to the transcript.)</p> <p>3 Q. The court reporter has just handed you</p> <p>4 what has been marked as Exhibit 1099.</p> <p>5 Are you familiar with this document?</p> <p>6 A. Yes.</p> <p>7 Q. It's titled "An Alphavirus-derived</p> <p>8 replicon RNA vaccine induces SARS-CoV-2</p> <p>9 neutralizing antibody in T-cell responses in mice</p> <p>10 and nonhuman primates." Is that right?</p> <p>11 A. That's right.</p> <p>12 Q. And you are the last author here?</p> <p>13 A. Correct.</p> <p>14 Q. You recognize this article. Right?</p> <p>15 A. Yes.</p> <p>16 Q. In fact, you're the corresponding author?</p> <p>17 A. Correct.</p> <p>18 Q. What does that mean?</p> <p>19 A. That means that I was the principal</p> <p>20 investigator in this study.</p> <p>21 Q. And as the principal investigator and</p> <p>22 corresponding author, you'd have reviewed this</p>
<p>34</p> <p>1 vaccines in the 1990 to '98 time frame.</p> <p>2 What delivery strategies did you use?</p> <p>3 A. Naked -- you understand what "naked"</p> <p>4 means -- Lipofectin and a gene gun.</p> <p>5 Q. I'm sorry. What was the last one?</p> <p>6 A. Gene gun.</p> <p>7 Q. What is Lipofectin?</p> <p>8 A. Lipofectin is a free agent used to</p> <p>9 facilitate transfection of nucleic acids into</p> <p>10 cells.</p> <p>11 Q. By October 2015, had you published any</p> <p>12 research related to mRNA vaccines?</p> <p>13 A. We didn't publish any of the negative</p> <p>14 data, which is typical among scientists. So while</p> <p>15 I did work with the mRNA vaccines, I did not</p> <p>16 publish any of that data. We only published the</p> <p>17 DNA vaccine positive results.</p> <p>18 Q. Is it fair to say that by October of 2015</p> <p>19 you hadn't published any research relating to mRNA</p> <p>20 vaccines?</p> <p>21 A. I hadn't published any of that data. No.</p> <p>22</p>	<p>36</p> <p>1 manuscript before it was published. Right?</p> <p>2 A. Correct.</p> <p>3 Q. And as the corresponding author, you would</p> <p>4 have done your best to ensure that every sentence</p> <p>5 in the manuscript is accurate. Is that fair?</p> <p>6 A. That's fair.</p> <p>7 Q. And you would have been familiar with the</p> <p>8 scientific literature that was cited within the</p> <p>9 publication. Is that fair?</p> <p>10 A. I would have been familiar with it. Yes.</p> <p>11 Q. You would have read that literature?</p> <p>12 A. Yes.</p> <p>13 Q. And you wouldn't have cited literature, of</p> <p>14 course, that you hadn't read. Right?</p> <p>15 A. No.</p> <p>16 Q. And it's fair to say that you would have</p> <p>17 done your best to make sure that the citations in</p> <p>18 the paper support the statements for which they're</p> <p>19 cited. Is that fair?</p> <p>20 A. That's right.</p> <p>21 Q. This article was published in August</p> <p>22 of 2020?</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 10 of 130

Conducted on August 2, 2024

<p>37</p> <p>1 A. Yes.</p> <p>2 Q. August 5th, 2020.</p> <p>3 August 2020 is, of course, after the</p> <p>4 COVID-19 vaccines -- excuse me -- pandemic began.</p> <p>5 Correct?</p> <p>6 A. Correct.</p> <p>7 Q. Let's take a look at a statement here in</p> <p>8 the abstract. The third sentence, I believe,</p> <p>9 says, "Here, we developed an Alphavirus-derived</p> <p>10 replicon RNA vaccine candidate, repRNA-CoV2S,</p> <p>11 encoding the SARS-CoV-2 spike protein." Is that</p> <p>12 right?</p> <p>13 A. That's right.</p> <p>14 Q. A replicon RNA vaccine can also be</p> <p>15 referred to as a self-amplifying mRNA vaccine. Is</p> <p>16 that right?</p> <p>17 A. Incorrect. It's referred to as a</p> <p>18 self-amplifying RNA vaccine.</p> <p>19 Q. A replicon RNA vaccine can also be</p> <p>20 referred to as a self-replicating mRNA vaccine.</p> <p>21 Right?</p> <p>22 A. Self-replicating RNA vaccine.</p>	<p>39</p> <p>1 Q. Administration of the RNA that was</p> <p>2 encoding for the SARS-CoV-2 spike protein resulted</p> <p>3 in expression in the body of the SARS-CoV-2 spike</p> <p>4 protein. Right?</p> <p>5 A. So you're referring to this paper again?</p> <p>6 Q. Yes.</p> <p>7 A. So injection -- this RNA vaccine was</p> <p>8 injected intramuscularly, and then the RNA would</p> <p>9 have been expressed in the muscle cells of that</p> <p>10 animal. There was a nonhuman primate or a mouse,</p> <p>11 and then that would express this spike protein.</p> <p>12 Q. When did you begin design of the vaccine</p> <p>13 candidate that's described here in this</p> <p>14 publication?</p> <p>15 A. January 7, 2020.</p> <p>16 Q. And you chose the SARS-CoV-2 spike protein</p> <p>17 as the antigen to be encoded in your vaccine</p> <p>18 candidate in January of 2020. Correct?</p> <p>19 A. That's correct.</p> <p>20 Q. And you could have selected other antigens</p> <p>21 to be encoded in your vaccine candidate. Right?</p> <p>22 A. Could have. Yes.</p>
<p>38</p> <p>1 Q. Is it your testimony that you've never</p> <p>2 heard of the term "self-amplifying mRNA"?</p> <p>3 A. I've heard people use it, but it's</p> <p>4 incorrectly used.</p> <p>5 Q. Why is it incorrectly used?</p> <p>6 A. Because self-amplifying RNA is not mRNA.</p> <p>7 Q. In your self-amplifying RNA vaccine</p> <p>8 candidate, the mRNA was encoding for the</p> <p>9 SARS-CoV-2 spike protein. Right?</p> <p>10 A. So the saRNA and the replicon RNA was</p> <p>11 encoding for the spike protein.</p> <p>12 Q. What is a spike protein?</p> <p>13 A. So the spike protein is the structural</p> <p>14 protein on a virus that the virus uses to infect a</p> <p>15 cell. So in the context of a vaccine, it is just</p> <p>16 the -- that subunit, that component of the viral</p> <p>17 protein.</p> <p>18 Q. Administration of the RNA coding for the</p> <p>19 SARS-CoV-2 spike protein resulted in an expression</p> <p>20 in the body of the SARS-CoV-2 spike protein. Is</p> <p>21 that fair?</p> <p>22 A. What's the question again?</p>	<p>40</p> <p>1 Q. Could have selected envelope protein?</p> <p>2 A. Yes.</p> <p>3 Q. Could have selected membrane protein?</p> <p>4 A. Sure.</p> <p>5 Q. Could have selected the nucleic acid</p> <p>6 protein?</p> <p>7 A. Sure.</p> <p>8 Q. You didn't select any of those, did you?</p> <p>9 A. We did not.</p> <p>10 Q. Why did you choose the SARS-CoV-2 spike</p> <p>11 protein as the antigen to be encoded in your</p> <p>12 vaccine candidate?</p> <p>13 A. We were familiar with the data from the</p> <p>14 SARS-CoV-2003 and the MERS outbreak that occurred</p> <p>15 and evidence that suggested that if you could</p> <p>16 raise decent neutralizing antibody responses</p> <p>17 against a spike protein that that should provide</p> <p>18 protection from infection.</p> <p>19 Q. You said the literature showed that you</p> <p>20 would expect to raise decent neutralizing antibody</p> <p>21 responses against a spike protein. Right?</p> <p>22 MR. PRUSSIA: Object to the form of the</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 11 of 130

Conducted on August 2, 2024

<p style="text-align: right;">41</p> <p>1 question.</p> <p>2 A. Could you reask that question, please?</p> <p>3 Q. Sure. The literature showed you that you</p> <p>4 would expect to raise a decent neutralizing</p> <p>5 antibody response against a spike protein. Right?</p> <p>6 MR. PRUSSIA: Same objection.</p> <p>7 A. So we would have had to do the experiments</p> <p>8 first.</p> <p>9 Q. I'm just trying to understand your</p> <p>10 testimony because I think you said earlier that</p> <p>11 you were familiar with the data from the</p> <p>12 SARS-CoV-2 and -- sorry -- MERS outbreak that</p> <p>13 occurred. Correct?</p> <p>14 A. That's right.</p> <p>15 Q. And from that outbreak there was evidence</p> <p>16 that suggested that you could raise decent</p> <p>17 neutralizing antibody responses against the spike</p> <p>18 protein. Right?</p> <p>19 A. That's not how I meant that.</p> <p>20 So basically what I meant was that those</p> <p>21 particular outbreaks provided evidence that the</p> <p>22 spike protein would be a target for neutralizing</p>	<p style="text-align: right;">43</p> <p>1 antigen to be encoded in your vaccine candidate?</p> <p>2 A. What specific literature?</p> <p>3 Q. Yeah.</p> <p>4 A. What papers?</p> <p>5 Q. Yeah.</p> <p>6 A. I can't recall that. Not without Googling</p> <p>7 for it.</p> <p>8 Q. Fair enough. In selecting the spike</p> <p>9 protein as the antigen, did you look only at</p> <p>10 literature involving other self-amplifying</p> <p>11 vaccines?</p> <p>12 A. No.</p> <p>13 Q. Why not?</p> <p>14 A. We looked at all vaccine literature.</p> <p>15 Q. Why didn't you just limit it to</p> <p>16 self-amplifying vaccines?</p> <p>17 A. There was not a lot of data about RNA in</p> <p>18 general -- in those RNA vaccines in general,</p> <p>19 whether it was self-amplifying or mRNA -- or DNA,</p> <p>20 for that matter. There just wasn't a lot of</p> <p>21 nucleic acid vaccine data.</p> <p>22 The majority of the vaccine approaches</p>
<p style="text-align: right;">42</p> <p>1 antibody. And if we could raise sufficient</p> <p>2 neutralizing antibodies against that target, we</p> <p>3 may have an effective vaccine.</p> <p>4 Q. And you testified that that should provide</p> <p>5 protection from infection. Correct?</p> <p>6 A. That's the hypothesis. Yeah.</p> <p>7 Q. In making your selection of the SARS-CoV-2</p> <p>8 spike protein, you relied on scientific</p> <p>9 literature. Correct?</p> <p>10 A. So we reviewed the literature from --</p> <p>11 coronavirus literature, particularly from the</p> <p>12 SARS-CoV outbreak, SARS-CoV-1 specifically, and</p> <p>13 the MERS-CoV outbreaks. That was where the</p> <p>14 majority of the scientific literature related to</p> <p>15 coronavirus vaccines was in 2020.</p> <p>16 Q. And why did you rely on that literature?</p> <p>17 A. Because those were coronaviruses.</p> <p>18 Q. So you thought that literature was</p> <p>19 informative for SARS-CoV-2 work. Correct?</p> <p>20 A. That's what we based it on. Yes.</p> <p>21 Q. And what literature did you rely on in</p> <p>22 choosing the SARS-CoV-2 spike protein as the</p>	<p style="text-align: right;">44</p> <p>1 that were favored in 2003 when the SARS-CoV-1 and</p> <p>2 then later for the MERS was relying on more</p> <p>3 traditional vaccine approaches. And that's what</p> <p>4 we looked at.</p> <p>5 Q. And those other nucleic acid vaccine</p> <p>6 publications informed decisions that you made when</p> <p>7 designing your own vaccine candidate. Fair?</p> <p>8 MR. PRUSSIA: Object to the form of the</p> <p>9 question.</p> <p>10 A. Do you want to restate that?</p> <p>11 Q. Those other nucleic acid vaccine</p> <p>12 publications that you mentioned informed your</p> <p>13 decisions that you made when designing your own</p> <p>14 vaccine candidate. Is that fair?</p> <p>15 MR. PRUSSIA: Same objection.</p> <p>16 A. I just want to specify that what I just</p> <p>17 said previously was that the majority of the</p> <p>18 literature was about traditional vaccines, not</p> <p>19 nucleic acid vaccines.</p> <p>20 And so it was more of a broader aspect,</p> <p>21 and also pathology data that -- just even data</p> <p>22 that looked at passive transfer of antibody.</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 12 of 130

Conducted on August 2, 2024

<p>45</p> <p>1 Q. Did you look at other nucleic acid vaccine</p> <p>2 publications in making decisions regarding design</p> <p>3 of your own saRNA vaccine candidate?</p> <p>4 A. We did not.</p> <p>5 Q. Why did you not choose the envelope</p> <p>6 protein as the antigen to be encoded in your</p> <p>7 self-amplifying mRNA vaccine?</p> <p>8 A. We actually did test other immunogens.</p> <p>9 It's just we ended up taking forward the one with</p> <p>10 the spike protein because it was the most</p> <p>11 immunogenic.</p> <p>12 Q. Which others did you test?</p> <p>13 A. All of them.</p> <p>14 Q. So you tested the membrane protein?</p> <p>15 A. E, M, N, and S.</p> <p>16 Q. You wouldn't have begun the in vivo</p> <p>17 testing described in this publication unless you</p> <p>18 had some expectation of success in terms of</p> <p>19 whether your candidate would induce some immune</p> <p>20 response. Is that fair?</p> <p>21 A. Prior to initiating an in vivo study, we</p> <p>22 do a number of experiments to give us some</p>	<p>47</p> <p>1 We had expression cassettes, all the</p> <p>2 elements. We had done a number of studies and</p> <p>3 published other studies using that DNA vaccine</p> <p>4 expressing, as I said, for example, influenza</p> <p>5 immunogens.</p> <p>6 Likewise, we were working with a nanolipid</p> <p>7 carrier for delivery of RNA in collaboration with</p> <p>8 a biotech company located in Seattle. And they</p> <p>9 provided the material for us.</p> <p>10 And we -- they had previously, in</p> <p>11 collaboration with another group, had demonstrated</p> <p>12 that particular delivery formulation, which they</p> <p>13 termed a LION, was able to induce significant</p> <p>14 responses using a Zika viral vaccine.</p> <p>15 So we had, essentially, as I talked about</p> <p>16 when describing a platform, we had the platform in</p> <p>17 place. And we were able to, very quickly when the</p> <p>18 sequence for SARS-CoV-2 was published, to insert</p> <p>19 different sequences into that platform and</p> <p>20 validate that the expected proteins were expressed</p> <p>21 and then from there move forward into animal</p> <p>22 studies.</p>
<p>46</p> <p>1 confidence that it could actually be immunogenic.</p> <p>2 A principle of those is we do an in vitro</p> <p>3 transfection of the vaccine, whether that's a DNA</p> <p>4 or self-amplifying RNA.</p> <p>5 And then we evaluate whether or not that</p> <p>6 expression set is expressing the anticipated</p> <p>7 protein.</p> <p>8 And then if it does, then we will use our</p> <p>9 delivery platforms that we know have been</p> <p>10 successful with other vaccines to deliver that</p> <p>11 particular vaccine into the mouse or animal.</p> <p>12 Q. You mentioned delivery platforms that you</p> <p>13 know have been successful with other vaccines.</p> <p>14 Right?</p> <p>15 A. So yes. In 2020 when -- we're talking</p> <p>16 about this paper right here?</p> <p>17 Q. Yes.</p> <p>18 A. In 2020, we had several platforms that had</p> <p>19 been optimized in my lab for use with other</p> <p>20 vaccines; for example, Zika and influenza. So we</p> <p>21 had, for example, a DNA vaccine delivered by gene</p> <p>22 gun.</p>	<p>48</p> <p>1 Q. Why did you rely on a particular delivery</p> <p>2 formulation that induced responses using a Zika</p> <p>3 vaccine and rely on that data for delivery of your</p> <p>4 vaccine candidate?</p> <p>5 A. So that just validates that our platform,</p> <p>6 all the components, the delivery formulation, the</p> <p>7 method of delivery, the elements of the expression</p> <p>8 cassette, all of that is in place. The only thing</p> <p>9 that's changing is the immunogen, the Zika swapped</p> <p>10 out per se in our SARS-CoV-2.</p> <p>11 Q. And would that same principle apply if the</p> <p>12 nucleic acid differed?</p> <p>13 MR. PRUSSIA: Object to the form of the</p> <p>14 question.</p> <p>15 A. Could you be more specific?</p> <p>16 Q. I can try.</p> <p>17 That same delivery system research that</p> <p>18 you mentioned as being reliable in informing your</p> <p>19 decision to move forward with such a carrier for a</p> <p>20 different immunogen, that would apply equally</p> <p>21 whether it was an mRNA that was being delivered or</p> <p>22 some other type of nucleic acid. Is that fair?</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 13 of 130

Conducted on August 2, 2024

<p>49</p> <p>1 A. No, I don't think that's fair.</p> <p>2 We would have to test that delivery</p> <p>3 formulation with that particular nucleic acid</p> <p>4 platform.</p> <p>5 It wouldn't be necessarily readily</p> <p>6 interchangeable. We don't know that. We'd have</p> <p>7 to do the experiments first.</p> <p>8 Q. Okay. Going back to your article, when</p> <p>9 you began the in vivo testing that you discuss in</p> <p>10 this article here, did you have an expectation</p> <p>11 that your vaccine candidate would induce some</p> <p>12 level of neutralizing antibody response?</p> <p>13 MR. PRUSSIA: Object to the form of the</p> <p>14 question.</p> <p>15 A. Do you want to reask that?</p> <p>16 Q. I can try. Sure.</p> <p>17 Going back to your article, when you began</p> <p>18 the in vivo testing that you discuss in this</p> <p>19 article here, did you have an expectation that</p> <p>20 your vaccine candidate would induce some level of</p> <p>21 neutralizing antibody response?</p> <p>22 MR. PRUSSIA: Same objection.</p>	<p>51</p> <p>1 candidate would induce an immune response. Is</p> <p>2 that fair?</p> <p>3 A. That was --</p> <p>4 MR. PRUSSIA: Object to the form.</p> <p>5 Q. That was your expectation?</p> <p>6 A. Yes.</p> <p>7 Q. And once you knew that the spike protein</p> <p>8 was expressing, you would expect that the vaccine</p> <p>9 candidate would have some level of a neutralizing</p> <p>10 antibody response. Is that fair?</p> <p>11 MR. PRUSSIA: Object to the form of the</p> <p>12 question.</p> <p>13 A. We had hypotheses that it was able to</p> <p>14 induce an immune response.</p> <p>15 Q. What was the basis for that hypothesis?</p> <p>16 A. Could you elaborate a little bit?</p> <p>17 Q. I don't think so. I think you said that</p> <p>18 you had hypotheses that it was able to induce an</p> <p>19 immune response. I think that was your testimony.</p> <p>20 I just want to understand what you meant</p> <p>21 when you said "hypotheses."</p> <p>22 A. Right. So it's just basic fundamental</p>
<p>50</p> <p>1 A. We had a hypothesis that it would induce</p> <p>2 an immune response, but we didn't have any</p> <p>3 particular expectation of the level.</p> <p>4 Q. You wouldn't have injected the mice if you</p> <p>5 didn't have some expectation of some level of</p> <p>6 neutralizing antibody response. Right?</p> <p>7 A. We would have injected mice based on the</p> <p>8 preliminary data that I told you about that we --</p> <p>9 as long as we knew that the spike protein was</p> <p>10 expressing.</p> <p>11 With any vaccine platform, you can't</p> <p>12 necessarily predict what types of immune responses</p> <p>13 it's going to induce unless you've already tested,</p> <p>14 say -- going from Zika to flu, going from, say,</p> <p>15 one flu hemagglutinin into another flu</p> <p>16 hemagglutinin, there would be a like expectation.</p> <p>17 But going from one pathogen to a completely</p> <p>18 different pathogen, we would have hypotheses but</p> <p>19 we still have to do the experiment.</p> <p>20 Q. Let me change my question a bit.</p> <p>21 Once you know that the spike protein is</p> <p>22 expressing, you would expect that the vaccine</p>	<p>52</p> <p>1 nucleic acid vaccine biology that when you have a</p> <p>2 DNA or an RNA vaccine and you can validate that it</p> <p>3 expresses a protein in vitro, then the hypothesis</p> <p>4 is that if you inject that DNA or RNA vaccine into</p> <p>5 an animal, the muscle cell, or in the case of gene</p> <p>6 gun delivery, the skin cell will express that</p> <p>7 antigen. You can give that antigen to express in</p> <p>8 animal, and the hypothesis is that it will elicit</p> <p>9 an immune response.</p> <p>10 Q. Part of that immune response will also be</p> <p>11 some level of neutralizing antibodies. Right?</p> <p>12 A. It depends on the antigen they're</p> <p>13 expressing.</p> <p>14 Q. Okay. Let's go back to the article for a</p> <p>15 moment and discuss something that you've already</p> <p>16 mentioned.</p> <p>17 In the abstract you wrote, "The RNA</p> <p>18 replicons were formulated with lipid inorganic</p> <p>19 nanoparticles (LIONS) that were designed to</p> <p>20 enhance vaccine stability, delivery, and</p> <p>21 immunogenicity." Right?</p> <p>22 A. This is in the abstract?</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

Conducted on August 2, 2024

<p>53</p> <p>1 Q. Yeah. Sorry. I think it's about six</p> <p>2 lines down, just after the sentence we were</p> <p>3 discussing a moment ago.</p> <p>4 A. Okay. Yes, I see that.</p> <p>5 Q. You have an understanding of delivery</p> <p>6 systems for nucleic acids. Correct?</p> <p>7 A. Certain delivery systems. Correct.</p> <p>8 Q. And a delivery system is needed for a</p> <p>9 spike protein encoding nucleic acid vaccine.</p> <p>10 Right?</p> <p>11 A. Could you ask that again? It seemed a</p> <p>12 little backwards.</p> <p>13 Q. A delivery system is necessary for a spike</p> <p>14 protein encoding nucleic acid vaccine. Correct?</p> <p>15 A. For a nucleic acid vaccine encoding a</p> <p>16 spike protein?</p> <p>17 Q. Let me change the order of it.</p> <p>18 In order to deliver a spike protein</p> <p>19 encoding nucleic acid vaccine, a delivery system</p> <p>20 is required. Is that fair?</p> <p>21 A. You can deliver it any way you want.</p> <p>22 Q. You and others elected to use a lipid</p>	<p>55</p> <p>1 Q. And you didn't decide to deliver the</p> <p>2 nucleic acid using some other lipid-based system.</p> <p>3 Right?</p> <p>4 A. We did actually experiment with a</p> <p>5 head-to-head comparison of this particular -- this</p> <p>6 isn't in the paper. This is unpublished data that</p> <p>7 we looked at other lipid systems.</p> <p>8 Q. What other lipid systems did you look at?</p> <p>9 A. So there was a lipid nanoparticle-based</p> <p>10 system that I had reached out to Drew Weissman,</p> <p>11 and he shared that with us so that we can use that</p> <p>12 in testing compared to that as another delivery</p> <p>13 system.</p> <p>14 Q. Did you look at any others?</p> <p>15 A. We -- I believe we looked at gene gun</p> <p>16 delivery.</p> <p>17 Q. Any others?</p> <p>18 A. I'm trying to remember those experiments.</p> <p>19 It was four years ago.</p> <p>20 Not that I can recall.</p> <p>21 Q. And what was the lipid nanoparticle-based</p> <p>22 system that you reached out to Drew Weissman</p>
<p>54</p> <p>1 nanoparticle system to deliver your spike protein</p> <p>2 encoding nucleic acid vaccine. Right?</p> <p>3 A. In this case, we used the LION.</p> <p>4 Q. In making the decision to use a lipid</p> <p>5 nanoparticle system to deliver your spike protein</p> <p>6 encoding nucleic acid vaccine, you consulted the</p> <p>7 scientific literature. Right?</p> <p>8 A. We consulted our preliminary data using</p> <p>9 that precise delivery formulation.</p> <p>10 Q. Is it your testimony that you didn't look</p> <p>11 to the scientific literature as well?</p> <p>12 A. Well, there was published data with the</p> <p>13 same formulation, but it was mostly -- this</p> <p>14 particular lipid inorganic nanoparticle was</p> <p>15 developed by the biotech company that we were</p> <p>16 collaborating with. And they had preliminary data</p> <p>17 demonstrating the conditions that I've described</p> <p>18 to you before that would support bringing that</p> <p>19 vaccine into an animal model.</p> <p>20 Q. You didn't decide to deliver the nucleic</p> <p>21 acid naked, did you?</p> <p>22 A. We didn't.</p>	<p>56</p> <p>1 about?</p> <p>2 A. It was whatever one was the one he was</p> <p>3 using at the time.</p> <p>4 Q. You don't remember?</p> <p>5 A. I don't remember. He swaps them around.</p> <p>6 Q. And what happened with that lipid</p> <p>7 nanoparticle-based system?</p> <p>8 A. It was fine.</p> <p>9 Q. It worked?</p> <p>10 A. It worked. It induced immune responses.</p> <p>11 Yeah. More information on that I can't provide</p> <p>12 because I'm under confidentiality with the biotech</p> <p>13 company that I collaborated with.</p> <p>14 Q. You didn't deliver the nucleic acid using</p> <p>15 a protamine-based delivery system, did you?</p> <p>16 A. Not in that study. I have done that</p> <p>17 before, though.</p> <p>18 Q. Why did you not go with a protamine-based</p> <p>19 delivery system here?</p> <p>20 A. We just didn't have it handy.</p> <p>21 Q. Okay. Let's go back to your article. The</p> <p>22 introduction at the bottom half of the page reads,</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 15 of 130

Conducted on August 2, 2024

<p>57</p> <p>1 "Severe acute respiratory syndrome" --</p> <p>2 Right under the title, "Introduction."</p> <p>3 -- "coronavirus-2 (SARS-CoV-2) first</p> <p>4 emerged in December 2019, and within 3 months,</p> <p>5 coronavirus disease 2019 (COVID-19), caused by</p> <p>6 SARS-CoV-2 infection, was declared a worldwide</p> <p>7 pandemic." Right?</p> <p>8 A. Right.</p> <p>9 Q. SARS-CoV-2 virus first emerged in</p> <p>10 December 2019. Right?</p> <p>11 A. That's what it says.</p> <p>12 Q. And the SARS-CoV-2 virus sequence was</p> <p>13 first published in early 2020. Right?</p> <p>14 A. On January 7th, 2020.</p> <p>15 Q. And before the virus was sequenced,</p> <p>16 someone in the field could not have designed a</p> <p>17 nucleic acid vaccine encoding the spike protein of</p> <p>18 SARS-CoV-2, could they?</p> <p>19 A. You need the sequence.</p> <p>20 Q. So similarly, someone in the field could</p> <p>21 not have designed an mRNA vaccine encoding the</p> <p>22 spike protein of SARS-CoV-2 until the virus was</p>	<p>59</p> <p>1 the context of an article describing vaccine</p> <p>2 development. Fair?</p> <p>3 A. Yes.</p> <p>4 Q. Do you recall when the function of the</p> <p>5 spike protein was known?</p> <p>6 A. I don't.</p> <p>7 Q. Was it before October of 2015?</p> <p>8 A. Likely.</p> <p>9 Q. Your article states that "Protection is</p> <p>10 thought to be mediated by neutralizing antibodies</p> <p>11 against the S protein, because most of the</p> <p>12 experimental vaccines developed against the</p> <p>13 related SARS-CoV-2 [sic] incorporated the</p> <p>14 S protein, or its receptor binding domain (RBD),</p> <p>15 with the goal of inducing robust, neutralizing</p> <p>16 antibody responses." Correct?</p> <p>17 A. That's right.</p> <p>18 I just want to remind myself which one.</p> <p>19 Q. I'm sorry. I misspoke. I said</p> <p>20 "SARS-CoV-2" and it should have been "SARS-CoV,"</p> <p>21 just for the record.</p> <p>22 A. Would you repeat the question, then?</p>
<p>58</p> <p>1 sequenced?</p> <p>2 A. You need the sequence.</p> <p>3 Q. Around six lines down in the introduction,</p> <p>4 the article further reads, "The S protein mediates</p> <p>5 the binding of coronaviruses to</p> <p>6 angiotensin-converting enzyme 2 (ACE2) on the</p> <p>7 surface of various cell types including epithelial</p> <p>8 cells at the pulmonary alveolus." Right?</p> <p>9 A. That's right.</p> <p>10 Q. When was it discovered that the S protein</p> <p>11 of coronaviruses mediates viral binding at entry?</p> <p>12 A. So for SARS-CoV-2 or just in general for</p> <p>13 SARS-CoV?</p> <p>14 Q. For SARS-CoV.</p> <p>15 A. Just in general. So that would have</p> <p>16 been -- I don't know exactly when. I don't have a</p> <p>17 date for you.</p> <p>18 Q. Would it have been before October 2015?</p> <p>19 A. Yeah, likely that would have been before</p> <p>20 then.</p> <p>21 Q. The function of the spike protein was</p> <p>22 understood as something relevant to highlight in</p>	<p>60</p> <p>1 Q. Yeah. Your article states that</p> <p>2 "Protection is thought to be mediated by</p> <p>3 neutralizing antibodies against the S protein,</p> <p>4 because most of the experimental vaccines</p> <p>5 developed against the related SARS-CoV</p> <p>6 incorporated the S protein, or its receptor</p> <p>7 binding domain (RBD), with the goal of inducing</p> <p>8 robust, neutralizing antibody responses." Right?</p> <p>9 A. That's what it says.</p> <p>10 Q. What does it mean that "Protection is</p> <p>11 thought to be mediated by neutralizing antibodies</p> <p>12 against the S protein"?</p> <p>13 A. What's meant by that is that the antibody</p> <p>14 generated against the S protein is thought to</p> <p>15 interfere with the ability of the virus to attach</p> <p>16 to and infect the cells.</p> <p>17 Q. When were most of the experimental</p> <p>18 vaccines developed against the related SARS-CoV</p> <p>19 developed?</p> <p>20 A. So that would have been shortly after the</p> <p>21 epidemic. So that would have been mostly around</p> <p>22 2005, 2004, 2003, maybe even -- beyond that, I'm</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 16 of 130

Conducted on August 2, 2024

<p style="text-align: right;">61</p> <p>1 not so sure there was much done simply because it</p> <p>2 was a short epidemic. People get excited about</p> <p>3 something and then it goes away.</p> <p>4 Q. So is it fair to say in the 2003 to 2005</p> <p>5 time frame experimental vaccines developed against</p> <p>6 related SARS-CoV informed the field such that</p> <p>7 protection would be thought to be mediated by</p> <p>8 neutralizing antibodies against the S protein?</p> <p>9 MR. PRUSSIA: Object to the form of the</p> <p>10 question.</p> <p>11 A. Could you restate that?</p> <p>12 Q. I can try. In the 2003 to 2005 time</p> <p>13 frame, there were experimental vaccines developed</p> <p>14 against related SARS-CoV. Correct?</p> <p>15 A. There were, yes.</p> <p>16 Q. And those studies from the 2003 to 2005</p> <p>17 time frame suggested that protection was thought</p> <p>18 to be mediated by neutralizing antibodies against</p> <p>19 the S protein. Correct?</p> <p>20 A. So the data from those studies</p> <p>21 demonstrated induction of neutralizing antibody.</p> <p>22 Many of those vaccines were designed -- for</p>	<p style="text-align: right;">63</p> <p>1 centered around SARS-CoV. It would have been</p> <p>2 around MERS. A lot of it had involved the</p> <p>3 S protein. Most of that was done with traditional</p> <p>4 vaccines. There was -- for example, recombinant</p> <p>5 protein vaccines were tested and activated</p> <p>6 vaccines were tested.</p> <p>7 There was a fair amount of concern</p> <p>8 surrounding S protein in the studies because there</p> <p>9 was in some -- several animal models evidence of</p> <p>10 enhanced infection when the S protein was used.</p> <p>11 And so researchers would explore other</p> <p>12 immunogens besides the S protein because of that</p> <p>13 concern about enhanced infectivity.</p> <p>14 Q. You are a researcher that explored other</p> <p>15 immunogens besides the S protein. Right?</p> <p>16 A. That's right.</p> <p>17 Q. And you chose the S protein ultimately.</p> <p>18 Right?</p> <p>19 A. We chose S protein for this particular</p> <p>20 study. Yeah.</p> <p>21 Q. The vaccines that we were discussing a</p> <p>22 moment ago against SARS-CoV that did incorporate</p>
<p style="text-align: right;">62</p> <p>1 example, the common protein vaccines only include</p> <p>2 the S protein. And the generation of the</p> <p>3 neutralizing antibody against an S protein</p> <p>4 corresponded with protection.</p> <p>5 Q. And you relied on those studies when you</p> <p>6 were developing a SARS-CoV-2 vaccine candidate.</p> <p>7 Right?</p> <p>8 A. We were looking at it. Yes.</p> <p>9 MR. PRUSSIA: Objection to the form of the</p> <p>10 question.</p> <p>11 Q. It was known by October 2015 that most of</p> <p>12 the vaccines developed against SARS-CoV</p> <p>13 incorporated the S protein or its receptor binding</p> <p>14 domain. Correct?</p> <p>15 A. So there were other vaccine candidates</p> <p>16 testing other immunogens as well, but there were</p> <p>17 quite a few of them focused on S protein.</p> <p>18 Q. So it was known by October 2015 that</p> <p>19 vaccines developed against SARS-CoV incorporated</p> <p>20 the S protein or its receptor binding domain.</p> <p>21 Right?</p> <p>22 A. So by 2015, there was quite a bit of data</p>	<p style="text-align: right;">64</p> <p>1 the S protein induced an immune response. Right?</p> <p>2 A. Which vaccine?</p> <p>3 MR. PRUSSIA: Object to the form.</p> <p>4 Go ahead.</p> <p>5 Q. A moment ago we were discussing vaccines</p> <p>6 developed against SARS-CoV that incorporated the</p> <p>7 S protein. Correct?</p> <p>8 A. Which vaccines again? Are we talking</p> <p>9 about this vaccine in my paper or are we talking</p> <p>10 about historically?</p> <p>11 Q. We're talking about historical vaccines.</p> <p>12 A. Okay.</p> <p>13 Q. Are you aware of any vaccines developed</p> <p>14 against SARS-CoV that incorporated the S protein,</p> <p>15 aside from the vaccine candidate discussed in your</p> <p>16 2020 paper?</p> <p>17 A. So are you referring to, in my references,</p> <p>18 9 through 11?</p> <p>19 Q. We'll get there. I'm just asking you</p> <p>20 first whether you are aware of any of those</p> <p>21 vaccines.</p> <p>22 A. I'm just going to check to see which ones</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 17 of 130

Conducted on August 2, 2024

<p style="text-align: right;">65</p> <p>1 we cited here.</p> <p>2 So these were mostly reviews. So it would</p> <p>3 have encompassed a lot of -- it would have</p> <p>4 reviewed a range of different SARS-CoV vaccines,</p> <p>5 including the ones that would use spike.</p> <p>6 Q. So there are a range of different SARS-CoV</p> <p>7 vaccines, some of which used spike protein.</p> <p>8 Correct?</p> <p>9 A. Correct.</p> <p>10 Q. And those SARS-CoV vaccines that used</p> <p>11 spike proteins induced immune response. Right?</p> <p>12 MR. PRUSSIA: Object to the form of the</p> <p>13 question.</p> <p>14 A. So could you be more specific?</p> <p>15 Q. Are you aware of any SARS-CoV vaccines</p> <p>16 using spike proteins that induced an immune</p> <p>17 response?</p> <p>18 A. Yes.</p> <p>19 Q. Which ones are you aware of?</p> <p>20 A. Pretty much every vaccine type out there.</p> <p>21 There was primarily inactivated recombinant</p> <p>22 protein, there was DNA vaccine. There were</p>	<p style="text-align: right;">67</p> <p>1 context of your publication.</p> <p>2 A. Right.</p> <p>3 Q. I am trying to understand what literature</p> <p>4 you reviewed in making certain design decisions</p> <p>5 when developing your self-amplifying RNA</p> <p>6 candidate. Okay?</p> <p>7 A. Uh-hmm.</p> <p>8 Q. And I think I asked you whether any of the</p> <p>9 previous vaccines against SARS-CoV included</p> <p>10 self-amplifying RNA candidates. I think the</p> <p>11 answer was no.</p> <p>12 A. To my knowledge, no.</p> <p>13 Q. What did you consider to make design</p> <p>14 choices when developing your saRNA vaccine</p> <p>15 candidate?</p> <p>16 A. So for this particular paper, as I</p> <p>17 mentioned, we already had pretty much the platform</p> <p>18 in place. We had already demonstrated this</p> <p>19 particular Alphavirus-derived replicon RNA vaccine</p> <p>20 encoding other immunogens formulated with the same</p> <p>21 lipid nanoparticle, called LION in this case,</p> <p>22 resulted in the induction of immune responses.</p>
<p style="text-align: right;">66</p> <p>1 others, various ones using different antigens</p> <p>2 formulated with different vaccines.</p> <p>3 Q. Were any of the previous vaccines against</p> <p>4 SARS-CoV self-amplifying RNA vaccines?</p> <p>5 A. To my knowledge, we did not find any</p> <p>6 self-amplifying RNA vaccines at that time.</p> <p>7 Q. Was previous experience with other</p> <p>8 non-self-amplifying vaccine modalities relevant to</p> <p>9 the development of the self-amplifying RNA vaccine</p> <p>10 candidate?</p> <p>11 A. Could you rephrase it? Are you referring</p> <p>12 specifically to SARS-CoV or are we going more big</p> <p>13 picture, general here?</p> <p>14 Q. Let me ask it a different way.</p> <p>15 Was previous experience with other</p> <p>16 non-self-amplifying vaccine modalities relevant to</p> <p>17 the development of a self-amplified RNA candidate</p> <p>18 encoding the S protein of SARS-CoV-2?</p> <p>19 A. Define what you mean by "non-self." Just</p> <p>20 anything that's not a self-amplifying --</p> <p>21 Q. I'm not trying to trick you. Just</p> <p>22 self-amplifying RNA vaccine candidates in the</p>	<p style="text-align: right;">68</p> <p>1 So it was already an established platform</p> <p>2 in our lab in 2020 when it came to this point.</p> <p>3 Q. Okay. Could we go back to your</p> <p>4 publication for a moment.</p> <p>5 And if we look at the second half of this</p> <p>6 sentence in your publication that we were just</p> <p>7 discussing, do you see it reads, "Most of the</p> <p>8 experimental vaccines developed against the</p> <p>9 related SARS-CoV incorporated the S protein, or</p> <p>10 its receptor binding domain (RBD), with the goal</p> <p>11 of inducing robust, neutralizing antibody</p> <p>12 responses." Do you see that?</p> <p>13 A. Yes.</p> <p>14 Q. And for that proposition, you cited a</p> <p>15 couple of references, 9 through 11.</p> <p>16 A. Uh-hmm.</p> <p>17 Q. Okay. Let's take a look at those for a</p> <p>18 moment.</p> <p>19 Are any of the References 9 through 11</p> <p>20 saRNA vaccines?</p> <p>21 A. So two of these references are reviews,</p> <p>22 one to summarize, in general, SARS vaccine</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 18 of 130

Conducted on August 2, 2024

<p>69</p> <p>1 development, and the other the spike protein</p> <p>2 SARS-CoV target for vaccine and therapeutic</p> <p>3 development.</p> <p>4 Q. In your article, Reference Number 11 is</p> <p>5 from L. Du. Do you see that?</p> <p>6 A. Yes.</p> <p>7 Q. And it's titled "A target for vaccine and</p> <p>8 therapeutic development."</p> <p>9 A. The spike protein is SARS-CoV, a target</p> <p>10 for vaccine therapeutic development. You mean</p> <p>11 that one. Right?</p> <p>12 Q. That one. Yeah. Thank you for that</p> <p>13 correction.</p> <p>14 And it's from 2009?</p> <p>15 A. Yes.</p> <p>16 Q. You cited to this piece of literature</p> <p>17 because you considered it to be valid scientific</p> <p>18 literature. Correct?</p> <p>19 A. Right.</p> <p>20 Q. And are you aware that that piece of</p> <p>21 literature has been marked as an exhibit or is an</p> <p>22 exhibit in this proceeding?</p>	<p>71</p> <p>1 well as protective immunity, during infection with</p> <p>2 SARS-CoV"?</p> <p>3 A. Uh-hmm.</p> <p>4 Q. It's fair to say, isn't it, that by March</p> <p>5 of 2009 the S protein of SARS-CoV was known to</p> <p>6 play key parts in the induction of</p> <p>7 neutralizing-antibody and T-cell responses as well</p> <p>8 as protective immunity during infection with</p> <p>9 SARS-CoV. Right?</p> <p>10 A. There was evidence supporting those.</p> <p>11 Q. On the next page, Du 2009, in the last</p> <p>12 line of the first paragraph, do you see where it</p> <p>13 says, "Because the S protein of SARS-CoV is</p> <p>14 involved in receptor recognition as well as virus</p> <p>15 attachment entry, it represents one of the most</p> <p>16 important targets for the development of SARS</p> <p>17 vaccines and therapeutics."</p> <p>18 A. I see that sentence.</p> <p>19 Q. And this exhibit, Du 2009, does not</p> <p>20 discuss self-amplifying RNA vaccine encoding the</p> <p>21 spike protein, does it?</p> <p>22 A. No, not to my knowledge.</p>
<p>70</p> <p>1 A. Yes.</p> <p>2 (Exhibit 1031, previously marked, is not</p> <p>3 attached to the transcript.)</p> <p>4 Q. So I've just handed Exhibit 1031 to you.</p> <p>5 And this is the Du 2009 article that's referenced</p> <p>6 at Reference 11 in your 2020 publication. Right?</p> <p>7 A. Uh-hmm.</p> <p>8 Q. And it was published in March of -- excuse</p> <p>9 me -- 2009?</p> <p>10 A. It's published in 2009. Yes.</p> <p>11 Q. Okay. The abstract of Du states that "The</p> <p>12 S protein plays key parts in the induction of</p> <p>13 neutralizing-antibody and T-cell responses, as</p> <p>14 well as protective immunity, during infection with</p> <p>15 SARS-CoV." Right?</p> <p>16 A. Where are you reading again?</p> <p>17 Q. I'm in the abstract. Apologies.</p> <p>18 A. All right.</p> <p>19 Q. It's about three lines down.</p> <p>20 Do you see where it says, "The S protein</p> <p>21 plays key parts in the induction of</p> <p>22 neutralizing-antibody and T-cell responses, as</p>	<p>72</p> <p>1 Q. And yet this is a relevant article that</p> <p>2 you elected to cite in your own publication</p> <p>3 regarding self-amplifying RNA vaccine encoding for</p> <p>4 the SARS-CoV-2 spike protein. Right?</p> <p>5 A. Just to be clear, the reference was in</p> <p>6 regard to the spike protein specifically, not to</p> <p>7 self-amplifying RNA vaccine.</p> <p>8 Q. Okay. Let's go back to 1099, your 2020</p> <p>9 publication. Got it?</p> <p>10 A. I do.</p> <p>11 Q. On page 1 it goes on to state, "Previous</p> <p>12 reports have shown that human neutralizing</p> <p>13 antibodies protected mice challenged with SARS-CoV</p> <p>14 and MERS-CoV, suggesting that protection against</p> <p>15 SARS-CoV-2 could be mediated through anti-S</p> <p>16 antibodies." Do you see that?</p> <p>17 A. I do see that.</p> <p>18 Q. And that's a true statement. Right?</p> <p>19 A. That's -- yes, citing works in which that</p> <p>20 was shown.</p> <p>21 Q. And it's citing work References 12, 13,</p> <p>22 14, and 15. Right?</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 19 of 130

Conducted on August 2, 2024

<p>73</p> <p>1 A. So all of those are really specific</p> <p>2 towards a study of the monoclonal antibody and</p> <p>3 what it's actually targeting in terms of</p> <p>4 antibodies, characterizing the antibody</p> <p>5 interaction with the spike protein.</p> <p>6 Q. In support of the statement "Previous</p> <p>7 reports have shown that human neutralizing</p> <p>8 antibodies protected mice challenged with SARS-CoV</p> <p>9 and Middle East respiratory syndrome (MERS)-CoV,</p> <p>10 suggesting that protection against SARS-CoV-2</p> <p>11 could be mediated through anti-S antibodies,"</p> <p>12 includes citations 12 through 15. Right?</p> <p>13 A. So that's referring to a passive transfer</p> <p>14 study where the antibodies would have been</p> <p>15 generated in humans, likely from somebody who had</p> <p>16 previously been infected, passively transferred to</p> <p>17 a mouse model a SARS-CoV or MERS-CoV infection and</p> <p>18 then the mice would have been challenged. They</p> <p>19 demonstrated protection.</p> <p>20 Q. Is it fair to say that protection against</p> <p>21 SARS-CoV-2 was known to be mediated or possibly</p> <p>22 mediated through anti-S antibodies in 2004, 2008,</p>	<p>75</p> <p>1 Q. And what time frame was that?</p> <p>2 A. The 1990s.</p> <p>3 MS. MAYS-WILLIAMS: We've been going for a</p> <p>4 little bit over an hour. Should we take a break?</p> <p>5 THE WITNESS: Sure.</p> <p>6 (Recess, 10:23 a.m. to 10:40 a.m.)</p> <p>7 (Fuller Exhibit 1100 was marked for</p> <p>8 identification and is not attached to the</p> <p>9 transcript.)</p> <p>10 BY MS. MAYS-WILLIAMS:</p> <p>11 Q. Okay. So the court reporter has just</p> <p>12 handed you a new exhibit, Exhibit Number 1100.</p> <p>13 This is an article titled "How mRNA and DNA</p> <p>14 vaccines could soon treat cancers, HIV, autoimmune</p> <p>15 disorders and genetic diseases." Right?</p> <p>16 A. That's right.</p> <p>17 Q. And this is an article that was written</p> <p>18 based on excerpts from a conversation that the</p> <p>19 author had with you. Correct?</p> <p>20 A. This was an interview. Yes.</p> <p>21 Q. And the article was published on</p> <p>22 January 24th, 2022. Right?</p>
<p>74</p> <p>1 and 2016 time frame?</p> <p>2 A. I'm sorry. Would you repeat that? You're</p> <p>3 talking about SARS-CoV-1 or --</p> <p>4 Q. I'll move on. Let's just move on.</p> <p>5 I want to go back to your article where it</p> <p>6 states, "Nucleic acid vaccines have emerged" --</p> <p>7 it's in the next paragraph. Do you see the first</p> <p>8 sentence there?</p> <p>9 A. Yes.</p> <p>10 Q. "Nucleic acid vaccines have emerged as</p> <p>11 ideal modalities for rapid vaccine design,</p> <p>12 requiring only the target antigen's gene</p> <p>13 sequence." Do you see that?</p> <p>14 A. Yes.</p> <p>15 Q. And when did that emerge as an ideal</p> <p>16 modality?</p> <p>17 A. So ideal, meaning theoretically, the idea</p> <p>18 that nucleic acid vaccines could enable rapid</p> <p>19 vaccine came about at the earliest conception of</p> <p>20 the idea of nucleic acid vaccines. That was the</p> <p>21 idea behind them, that they could be rapidly</p> <p>22 designed.</p>	<p>76</p> <p>1 A. That's what it says. Yeah.</p> <p>2 Q. Do you recall when the interview was?</p> <p>3 A. I don't recall the precise date, but</p> <p>4 generally for these articles it's within three to</p> <p>5 four weeks.</p> <p>6 Q. And did you review the final article after</p> <p>7 the -- you gave the interview?</p> <p>8 A. So I did review a draft of the text, but</p> <p>9 the final article would have been reviewed by the</p> <p>10 editor.</p> <p>11 Q. Did you make any comments or edits to the</p> <p>12 draft?</p> <p>13 A. I don't recall. I probably did.</p> <p>14 Q. Okay. The first heading of this article</p> <p>15 reads, "How long have gene-based vaccines been in</p> <p>16 development?" Right?</p> <p>17 A. Yes.</p> <p>18 Q. And the first sentence of that section</p> <p>19 says, "This type of vaccine has been in the works</p> <p>20 for about 30 years." Right?</p> <p>21 A. That's right.</p> <p>22 Q. And what does "this type of vaccine" mean?</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 20 of 130

Conducted on August 2, 2024

<p>77</p> <p>1 A. Nucleic acid vaccine or gene-based</p> <p>2 vaccine.</p> <p>3 Q. The next sentence reads, "Nucleic</p> <p>4 acids" -- excuse me -- "Nucleic acid vaccines are</p> <p>5 based on the idea that DNA makes RNA and then RNA</p> <p>6 makes proteins."</p> <p>7 That's a correct statement. Right?</p> <p>8 A. Yes, in general. We had to keep in mind</p> <p>9 that these articles are written for the general</p> <p>10 public, so we don't put a lot of additional</p> <p>11 technical detail into it.</p> <p>12 Q. Both DNA and RNA can encode a protein.</p> <p>13 Right?</p> <p>14 A. So they do encode the sequences that will</p> <p>15 ultimately make a protein. Yes.</p> <p>16 Q. In the case of DNA, the genes encoding a</p> <p>17 protein are first transcribed into mRNA and then</p> <p>18 translated by the cell into the encoded protein.</p> <p>19 Right?</p> <p>20 A. That's right.</p> <p>21 Q. And in the case of mRNA, the mRNA is just</p> <p>22 directly translated into the encoded protein?</p>	<p>79</p> <p>1 the sequence encoded by the RNA or DNA is</p> <p>2 expressing properly folded protein and the like.</p> <p>3 Q. Let's go to the next page. If you'd turn</p> <p>4 to the -- hang on a second. Okay. If you'd turn</p> <p>5 to page 2, the last sentence of the first</p> <p>6 paragraph.</p> <p>7 A. The last sentence of the first paragraph?</p> <p>8 Q. It says "For a very long time DNA vaccines</p> <p>9 took the front seat, and the very first clinical</p> <p>10 trials were with the DNA vaccine." Do you see</p> <p>11 that?</p> <p>12 A. I do.</p> <p>13 Q. And then after that it says, "But about</p> <p>14 seven or eight years ago, mRNA vaccines started to</p> <p>15 take the lead." Do you see that?</p> <p>16 A. Yes.</p> <p>17 Q. And we noted this at the start, but this</p> <p>18 article was published in January of 2022. Right?</p> <p>19 A. Uh-hmm.</p> <p>20 Q. So in your view, is it fair to say that</p> <p>21 around 2014, 2015, mRNA vaccines started to take</p> <p>22 the lead over DNA vaccines?</p>
<p>78</p> <p>1 A. Correct.</p> <p>2 Q. But both DNA and mRNA lead to expression</p> <p>3 of the encoded proteins. Right?</p> <p>4 A. Ultimately, yes.</p> <p>5 Q. And your article proceeds, "For any given</p> <p>6 protein, once we know the genetic sequence or</p> <p>7 code, we can design an mRNA or DNA molecule that</p> <p>8 prompts a person's cells to start making it."</p> <p>9 Right?</p> <p>10 A. That's right.</p> <p>11 Q. So someone in the field could design</p> <p>12 either DNA or mRNA encoding for a protein. Right?</p> <p>13 A. So somebody with -- a POSA, yeah, would be</p> <p>14 able to -- once they had the genetic code be able</p> <p>15 to design an RNA or DNA molecule and encoding</p> <p>16 that.</p> <p>17 Q. Is it fair to say that a POSA would</p> <p>18 reasonably expect that an administered RNA or DNA</p> <p>19 molecule will prompt a person's cells to start</p> <p>20 making it?</p> <p>21 A. Provided they do all those checks that we</p> <p>22 talked about earlier in terms of validating that</p>	<p>80</p> <p>1 A. I would say it would be more like 2016.</p> <p>2 Q. In this article it says seven or eight</p> <p>3 years ago.</p> <p>4 A. Yeah. It's a little kind of hand waving</p> <p>5 in that article.</p> <p>6 Q. But at the time when you gave the</p> <p>7 interview in -- sometime prior to January 2022,</p> <p>8 you believed that to be true?</p> <p>9 A. Well, when we were -- and when I was</p> <p>10 interviewed, yeah, that's probably what I said.</p> <p>11 But in reality, I would say mRNA vaccines</p> <p>12 did not start to really become prominent until --</p> <p>13 it was probably about 2016 that we began to take</p> <p>14 more notice of the capability of mRNA vaccines to</p> <p>15 potentially outperform DNA vaccines.</p> <p>16 Q. So at some time seven or eight years prior</p> <p>17 to 2022, mRNA vaccines started to take the lead</p> <p>18 over DNA vaccines. Fair?</p> <p>19 A. So more precisely, I would say we started</p> <p>20 to see mRNA vaccines in 2016 start to look</p> <p>21 promising along the same lines as either</p> <p>22 performing equal or superior to DNA vaccines.</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 21 of 130

Conducted on August 2, 2024

<p>81</p> <p>1 By 2017, 2018, there was a lot more</p> <p>2 enthusiasm about mRNA vaccines, particularly for</p> <p>3 cancer vaccines, which we're not really talking</p> <p>4 specifically at this point whether this is</p> <p>5 infectious diseases or cancers and the like.</p> <p>6 I would say a little bit earlier for mRNA</p> <p>7 vaccines for cancer, there became some additional</p> <p>8 interest. But for infectious diseases, I would</p> <p>9 say they probably did not take much prominence</p> <p>10 until about 2017 or 2018.</p> <p>11 And just to clarify that this article was</p> <p>12 a really broad sort of article about mRNA and DNA</p> <p>13 vaccines for cancers, infectious diseases, and</p> <p>14 other diseases as well, including genetic diseases</p> <p>15 such as for gene therapy.</p> <p>16 There was some interest particularly for</p> <p>17 both DNA and mRNA for gene therapy for a number of</p> <p>18 years as well.</p> <p>19 So let me just clarify the statement.</p> <p>20 When we say seven or eight years ago,</p> <p>21 we're kind of thinking more broadly about interest</p> <p>22 in mRNA vaccines. But talking about them taking</p>	<p>83</p> <p>1 vaccines. Fair?</p> <p>2 A. So it depends. It depends.</p> <p>3 Q. What are some advantages that mRNA</p> <p>4 vaccines provide over DNA vaccines?</p> <p>5 A. So some of the theoretical advantages</p> <p>6 include the fact that DNA when it gets delivered</p> <p>7 into the body is still -- into a cell, it still</p> <p>8 has to make its way into the nucleus before it can</p> <p>9 be transcribed and then that transcribed mRNA make</p> <p>10 protein.</p> <p>11 mRNA vaccines, you inject them in. They</p> <p>12 only need to get in the cell. So they don't have</p> <p>13 as far to go, so to speak.</p> <p>14 And the theory is that that's -- they</p> <p>15 would hold more potential to express more protein</p> <p>16 once injected in the body simply because they</p> <p>17 don't have that additional barrier of having to</p> <p>18 get into the nucleus.</p> <p>19 Q. What publications or research do you</p> <p>20 consider showing that vaccines started -- mRNA</p> <p>21 vaccines started to take the lead over DNA</p> <p>22 vaccines?</p>
<p>82</p> <p>1 the lead in terms of infectious diseases, I would</p> <p>2 not say that was until 2016 or 2017.</p> <p>3 Q. Why did you say seven or eight years ago</p> <p>4 in the article, then, that mRNA vaccines started</p> <p>5 to take the lead?</p> <p>6 A. So as I mentioned, when -- for this</p> <p>7 particular interview, sort of hand waving</p> <p>8 approximate number of years, I didn't have the</p> <p>9 opportunity to look it up. And so just in the</p> <p>10 back of my mind that seemed like about the right</p> <p>11 period of time.</p> <p>12 But if you wanted to -- if you asked me</p> <p>13 what year did mRNA vaccines actually start to take</p> <p>14 prominence over DNA vaccines, I would have more</p> <p>15 specified 2016 or 2017.</p> <p>16 MR. PRUSSIA: Just to be clear, she didn't</p> <p>17 write this article.</p> <p>18 MS. MAYS-WILLIAMS: I think we already</p> <p>19 established that.</p> <p>20 MR. PRUSSIA: Your question suggested that</p> <p>21 she did write the article.</p> <p>22 Q. mRNA vaccines provide advantages over DNA</p>	<p>84</p> <p>1 A. Let me try to remember which papers came</p> <p>2 out that started to raise some enthusiasm.</p> <p>3 I think the first time I actually realized</p> <p>4 that mRNA vaccines were going to hold some promise</p> <p>5 was a seminar that Drew Weissman did at the</p> <p>6 University of Washington in 2016, where he</p> <p>7 presented unpublished data at that point comparing</p> <p>8 mRNA to DNA vaccines.</p> <p>9 And then in 2017, he and I partnered with</p> <p>10 another researcher to propose to -- wrote up a</p> <p>11 BARDA application proposing that nucleic acid</p> <p>12 vaccines would be the answer to quickly respond to</p> <p>13 a future pandemic.</p> <p>14 And we proposed to compare head-to-head</p> <p>15 DNA, mRNA, and self-amplifying RNA, using</p> <p>16 influenza as a model because we all thought</p> <p>17 influenza was going to be the next pandemic or</p> <p>18 likely to be the next pandemic.</p> <p>19 So we submitted that in 2017. And the</p> <p>20 application unfortunately was not funded. The</p> <p>21 reviewers said that basically the prospects for</p> <p>22 nucleic acid vaccines working in humans was not</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 22 of 130

Conducted on August 2, 2024

<p>85</p> <p>1 promising.</p> <p>2 There were no nucleic vaccines licensed</p> <p>3 for human use and there had been a lot of failures</p> <p>4 before, so there was a lot of skepticism that our</p> <p>5 approach could be the answer for a future</p> <p>6 pandemic.</p> <p>7 Q. A minute ago your counsel pointed out that</p> <p>8 you didn't actually write this. Right?</p> <p>9 A. I was interviewed and then the journalist</p> <p>10 wrote it. The journalist shared the article with</p> <p>11 me, and then the final version of that goes to the</p> <p>12 editor.</p> <p>13 Q. And the journalist, did they pick out</p> <p>14 the -- excuse me -- the references that are cited</p> <p>15 in this or did you provide it to the journalist?</p> <p>16 A. So the journalist provided some</p> <p>17 references. I reviewed them. I provided other</p> <p>18 ones if they needed those.</p> <p>19 Q. So you would have signed off on all the</p> <p>20 references that are in here?</p> <p>21 A. I checked all of the references in there.</p> <p>22 Yes.</p>	<p>87</p> <p>1 Q. And you would have reviewed the article</p> <p>2 that's at the hyperlink. Correct?</p> <p>3 A. I don't recall what article it was.</p> <p>4 Q. Okay. We'll get there.</p> <p>5 A. Okay.</p> <p>6 Q. What is the problem of mRNA instability?</p> <p>7 A. Could you be more specific about what it</p> <p>8 is -- what you mean by -- what is the question</p> <p>9 you're asking?</p> <p>10 Q. Well, your reference refers to -- or,</p> <p>11 excuse me, this article, just based on an</p> <p>12 interview that you gave, references problems with</p> <p>13 instability in mRNA.</p> <p>14 A. Uh-hmm.</p> <p>15 Q. So I'm just asking you what are those</p> <p>16 problems.</p> <p>17 A. mRNA being unstable?</p> <p>18 Q. Yes.</p> <p>19 A. That is the problem. mRNA is inherently</p> <p>20 unstable.</p> <p>21 Q. Okay. How is the problem of mRNA inherent</p> <p>22 instability solved?</p>
<p>86</p> <p>1 Q. The article states that "Researchers</p> <p>2 solved a lot of the problems - notably the</p> <p>3 instability" regarding mRNA vaccines. Right? And</p> <p>4 there is a hyperlink there?</p> <p>5 MR. PRUSSIA: Objection.</p> <p>6 A. What's the question?</p> <p>7 Q. The article says, "Researchers solved a</p> <p>8 lot of the problems - notably the instability -</p> <p>9 and discovered new technologies to deliver mRNA</p> <p>10 into cells and ways of modifying the coding</p> <p>11 sequence to make the vaccines a lot more safe to</p> <p>12 use in humans." Do you see that?</p> <p>13 A. I do see that.</p> <p>14 Q. And the instability that's referred to</p> <p>15 here, that refers to instability of the mRNA.</p> <p>16 Right?</p> <p>17 A. In this article, we are referring to</p> <p>18 instability of mRNA.</p> <p>19 Q. And when you refer to researchers having</p> <p>20 solved a lot of the instability problems with</p> <p>21 mRNA, there's a hyperlink. Right?</p> <p>22 A. Yes.</p>	<p>88</p> <p>1 A. So for mRNA, delivery of mRNA, the primary</p> <p>2 means that improve their stability was the</p> <p>3 development of nanocarriers, lipo -- liposomes,</p> <p>4 those sorts of things that protect the mRNA from</p> <p>5 degradation from RNases in the body.</p> <p>6 Q. Is there -- are there any other</p> <p>7 instability problems that were solved outside of</p> <p>8 the development of lipid nanoparticle delivery</p> <p>9 systems?</p> <p>10 A. There probably are, but that's the main</p> <p>11 one I'm referring to in this article.</p> <p>12 Q. Okay.</p> <p>13 (Exhibit 1022, previously marked, is not</p> <p>14 attached to the transcript.)</p> <p>15 Q. I'm handing you what has already been</p> <p>16 marked as Exhibit 1022. I'll represent to you</p> <p>17 that this is actually the article that is</p> <p>18 hyperlinked with the word "instability."</p> <p>19 A. Okay.</p> <p>20 MR. PRUSSIA: I'll just object and say it</p> <p>21 lacks foundation.</p> <p>22 Q. Do you have any doubt that this is the</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 23 of 130

Conducted on August 2, 2024

<p style="text-align: right;">89</p> <p>1 reference that was hyperlinked --</p> <p>2 A. I would have to do it myself just to</p> <p>3 confirm. I'll accept that you're presenting me</p> <p>4 with the right article. I can't know for sure.</p> <p>5 Q. Okay. So the article that I've just</p> <p>6 placed in front of you is titled, "Incorporation</p> <p>7 of Pseudouridine Into mRNA Yields Superior</p> <p>8 Nonimmunogenetic Vector With Increased</p> <p>9 Translational Capacity and Biological Stability."</p> <p>10 Do you see that?</p> <p>11 A. Yes, I do see that.</p> <p>12 Q. And this is a publication by first author</p> <p>13 Katalin Karikó?</p> <p>14 A. Uh-hmm.</p> <p>15 Q. And last author Drew Weissman?</p> <p>16 A. Correct.</p> <p>17 Q. And it's published in November 2008?</p> <p>18 A. Yes.</p> <p>19 Q. And is it fair to say that it was</p> <p>20 Dr. Karikó and Dr. Weissman who were actually</p> <p>21 credited with solving the problem of mRNA</p> <p>22 stability?</p>	<p style="text-align: right;">91</p> <p>1 referenced instability and cited this article</p> <p>2 which does refer to solving the problem of</p> <p>3 biological instability.</p> <p>4 MR. PRUSSIA: Objection, lacks foundation.</p> <p>5 Go ahead.</p> <p>6 Q. Correct?</p> <p>7 A. So repeat the question.</p> <p>8 Q. When you gave this interview in 2022, you</p> <p>9 referenced instability, in this article -- excuse</p> <p>10 me.</p> <p>11 When you gave this interview in 2022, you</p> <p>12 referenced instability and cited to this article,</p> <p>13 which does solve the problem of mRNA biological</p> <p>14 instability. Is that fair?</p> <p>15 MR. PRUSSIA: Object to the form of the</p> <p>16 question, lacks foundation.</p> <p>17 A. So it doesn't completely solve all of the</p> <p>18 stability problems of mRNA.</p> <p>19 Q. But you cited this article when you</p> <p>20 referenced solving instability in the article that</p> <p>21 we were looking at before you did in 2022?</p> <p>22 MR. PRUSSIA: Same objection, no</p>
<p style="text-align: right;">90</p> <p>1 A. So this particular article was really</p> <p>2 focused on a -- the pseudouridine modification to</p> <p>3 dampen the immunogenicity of the RNA and the</p> <p>4 protein it expresses as the primary focus of this</p> <p>5 manuscript.</p> <p>6 Q. And that link -- I'm sorry.</p> <p>7 A. The stability that it refers to is</p> <p>8 referring to the fact that if you don't raise</p> <p>9 robust immunogenicity against the RNA or the</p> <p>10 protein it produces, then theoretically that would</p> <p>11 increase in vivo bioavailability, stability of the</p> <p>12 product itself.</p> <p>13 So not the instability that we're talking</p> <p>14 about with mRNA vaccines, some of the problems to</p> <p>15 be solved is just when you formulate mRNA vaccines</p> <p>16 and get them ready to inject that you have a</p> <p>17 stability problem.</p> <p>18 As I talked about earlier today, that in</p> <p>19 the early 1990s when we were testing mRNA, we had</p> <p>20 issues with them working because they were too</p> <p>21 unstable before we even injected them in the body.</p> <p>22 Q. When you gave this interview in 2022, you</p>	<p style="text-align: right;">92</p> <p>1 foundation.</p> <p>2 Q. Right?</p> <p>3 A. The question again?</p> <p>4 Q. You cited to this article when you were</p> <p>5 referencing the problem of mRNA instability when</p> <p>6 you were giving an interview that was published in</p> <p>7 January of 2022. Right?</p> <p>8 MR. PRUSSIA: Object to the form of the</p> <p>9 question, no foundation.</p> <p>10 A. I'm distracted, so if you could ask the</p> <p>11 question again?</p> <p>12 Q. Is it your counsel's objections that are</p> <p>13 distracting?</p> <p>14 You cited to this article when you were</p> <p>15 referencing the problem of mRNA instability when</p> <p>16 you were giving an interview that was published in</p> <p>17 January of 2022. Right?</p> <p>18 MR. PRUSSIA: Same objections.</p> <p>19 A. So I do not recall if I was the one who</p> <p>20 identified this particular reference for that, for</p> <p>21 that hyperlink. And I don't know if there are</p> <p>22 other -- without going into the article itself,</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 24 of 130

Conducted on August 2, 2024

<p style="text-align: right;">93</p> <p>1 whether there are other cited references in there</p> <p>2 as well.</p> <p>3 Q. You know Drew Weissman. Right?</p> <p>4 A. I do.</p> <p>5 Q. What is he credited with?</p> <p>6 A. So he and Karikó are credited with the</p> <p>7 discovery that pseudouridine, incorporation of</p> <p>8 pseudouridine into mRNA can dampen its recognition</p> <p>9 by the immune system.</p> <p>10 Q. Does that have any impact on stability of</p> <p>11 the mRNA in the body?</p> <p>12 A. So mRNA in the body is influenced by a</p> <p>13 number of different things, including the RNases</p> <p>14 themselves that can degrade the RNA. That's one</p> <p>15 stability I'm referring to.</p> <p>16 The other stability is with respect to an</p> <p>17 immune response, the mRNA can -- is a natural</p> <p>18 innate immune trigger. An immune response could</p> <p>19 shut down mRNA. So those are the stability</p> <p>20 aspects.</p> <p>21 But this particular article does not refer</p> <p>22 to the stability of mRNA protection from RNases.</p>	<p style="text-align: right;">95</p> <p>1 promising tool for both gene replacement and</p> <p>2 vaccination." Right?</p> <p>3 A. That's what it says.</p> <p>4 Q. And this is an article from 2008. Right?</p> <p>5 A. Uh-hmm.</p> <p>6 Q. So by 2008, it was known that</p> <p>7 incorporation of modified nucleosides enhanced</p> <p>8 mRNA stability. Right?</p> <p>9 MR. PRUSSIA: Object to the form of the</p> <p>10 question.</p> <p>11 A. Again, define "stability" and what you</p> <p>12 mean. I've defined "stability" in the context of</p> <p>13 what I think this article is referring to.</p> <p>14 Q. Biological stability.</p> <p>15 A. In vivo. Yes. Inside. Once it gets</p> <p>16 inside the body, it's dampening the immune</p> <p>17 response to the recognition of the mRNA.</p> <p>18 Q. It's increasing the biological stability</p> <p>19 of mRNA in the body?</p> <p>20 A. So the mRNA can actually last long enough</p> <p>21 to make the protein.</p> <p>22 Q. These improvements, which were published</p>
<p style="text-align: right;">94</p> <p>1 Q. It refers to -- actually, let's just look</p> <p>2 at what it refers to.</p> <p>3 The first sentence of the abstract in</p> <p>4 Exhibit 1022 teaches "In vitro -- transcribed</p> <p>5 mRNAs encoding physiologically important proteins</p> <p>6 have considerable potential for therapeutic</p> <p>7 applications. However, in its present form, mRNA</p> <p>8 is unfeasible for clinical use because of its</p> <p>9 labile and immunogenic nature." Right?</p> <p>10 A. Yes.</p> <p>11 Q. And we've talked about the labile nature</p> <p>12 of mRNA earlier today. Correct?</p> <p>13 A. We talked about, yeah, how they are</p> <p>14 inherently labile even when they're outside of the</p> <p>15 body.</p> <p>16 Q. This article, if you go to the last two</p> <p>17 sentences of the abstract, it says, "These</p> <p>18 findings indicate that nucleoside modification is</p> <p>19 an effective approach to enhance stability and</p> <p>20 translational capacity of mRNA while diminishing</p> <p>21 its immunogenicity in vivo. Improved properties</p> <p>22 conferred by pseudouridine make such mRNA a</p>	<p style="text-align: right;">96</p> <p>1 by November 2008, made clear that improvements --</p> <p>2 improved properties associated with nucleoside</p> <p>3 modified mRNA, made mRNA a promising tool for both</p> <p>4 gene replacement and vaccination. Right?</p> <p>5 MR. PRUSSIA: Objection to the form of the</p> <p>6 question.</p> <p>7 A. So let me clarify what the article is</p> <p>8 about. This is an article that is focused on</p> <p>9 making mRNA a potential tool for therapeutics, as</p> <p>10 described in the first sections, has considerable</p> <p>11 potential for therapeutic applications.</p> <p>12 And so the point -- we have to remember,</p> <p>13 with mRNA there's really two very opposing polar</p> <p>14 objectives with them.</p> <p>15 Early in the development of both mRNA and</p> <p>16 DNA, before even the conceptualization of using</p> <p>17 them for vaccination, there was a thinking that</p> <p>18 perhaps it could be used for gene therapy to</p> <p>19 replace, say, a gene that's missing or to replace</p> <p>20 a protein that is not being made in the body.</p> <p>21 And so there's an opposing objective when</p> <p>22 you think about that because when you want to</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 25 of 130

Conducted on August 2, 2024

<p style="text-align: right;">97</p> <p>1 replace a protein in the body, you do not want to 2 generate an immune response against it. 3 And so in this particular paper, this was 4 the focus of Karikó and Drew Weissman, is focusing 5 on how can we make mRNA which in its natural form 6 is unstable, is recognized by the immune system 7 and can generate immune responses, how could we 8 make mRNA a tool for a therapeutic. 9 So the studies showed that the 10 incorporation of pseudouridine enabled dampening 11 of the immune response so that they actually 12 didn't get any immune response against the encoded 13 protein. 14 And then in some of the most compelling 15 data here where they actually show that, not only 16 do they get reduced -- no immune response against 17 it, but they get higher amounts of protein 18 production. 19 And that's thought to be because the 20 immune response isn't shutting down the mRNA's 21 ability to make the protein. 22 So that's what this particular paper is</p>	<p style="text-align: right;">99</p> <p>1 that back up later on, but they said that could 2 also be used for vaccination. But then they had 3 to clarify that "In the latter case, 4 coadministration of adjuvant would be" -- "would 5 also be required." 6 And it's all theoretical because they have 7 no data and they have nothing to support the idea 8 that this particular pseudouridine modified mRNA 9 in 2008 would have been an effective vaccine. 10 Q. Got it. But when you gave this interview, 11 which is memorialized in an article before us that 12 was published in January of 2022, in the context 13 of mRNA vaccines and in the context of mRNA 14 stability, you made the decision to cite this 15 article. Is that fair? 16 MR. PRUSSIA: Objection. I'm sorry. I 17 had to clear my throat. Objection, lacks 18 foundation. 19 MS. MAYS-WILLIAMS: I'm trying to 20 establish a foundation. 21 A. I did not necessarily make the decisions 22 on all of the articles that were cited.</p>
<p style="text-align: right;">98</p> <p>1 about. It's completely opposite of what you want 2 if you want to make an mRNA into a vaccine, which 3 is you want to generate an immune response. 4 Q. Can you do me a favor and just read the 5 last sentence of the abstract into the record. 6 A. So the last sentence says, "Improved 7 properties conferred by pseudouridine make such 8 mRNA a promising tool for both gene replacement 9 and vaccination." 10 Now, as a scientist in the field, I view 11 that last word "and vaccination" with complete 12 skepticism based on this article for a number of 13 reasons. 14 One, there's absolutely no data in this 15 article that shows anything remotely related to 16 vaccination, generation of an immune response to 17 protect from pathogenic disease. 18 In fact, if anything, it would teach away 19 from vaccines because it's showing that it's 20 killing the immune response, which is not 21 something that you want in a vaccine. 22 And then in the discussion they do bring</p>	<p style="text-align: right;">100</p> <p>1 The second thing that I want to point out 2 is that this entire thing is not just about 3 vaccines. It's about therapeutics, use of mRNA 4 for therapeutics as well. 5 So there is a stability question that 6 we're addressing. We're talking about mRNA in a 7 bigger picture, not just about as a vaccine 8 against infectious diseases, but say a vaccine for 9 cancer. We're talking about therapeutics. 10 And mRNA for various different indications 11 were at different stages of development at the 12 time. 13 The instability -- this particular article 14 being cited there for that instability certainly 15 is valid for -- in the sense of the therapeutic in 16 terms of increasing the stability of the mRNA in 17 the body so that it has enough time to make 18 sufficient amounts of protein for a therapeutic 19 effect. 20 Q. You reviewed a draft of this article and 21 approved it before it was published. Right? 22 A. I did not review -- the final draft was</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 26 of 130

Conducted on August 2, 2024

<p style="text-align: right;">101</p> <p>1 reviewed by the editor. So there could have been 2 additional changes after. 3 So I reviewed the author's initial draft, 4 and then it goes to the editor and the editor 5 makes the final decisions on everything that gets 6 incorporated. 7 Q. Let's go back to this article, which I see 8 that you have in front of you. There's another 9 technological development that's discussed in this 10 article, which again is based on an interview that 11 you gave. 12 And the second technological development 13 that's noted is that researchers discovered new 14 technologies to deliver mRNA. 15 A. Could you show me where? 16 Q. Yeah. I'm actually in the same place. 17 It's right above that picture there. It's the 18 second paragraph -- the second sentence of the 19 second paragraph. 20 And now I'm just focusing on the new 21 technologies, the second hyperlink. 22 A. "And discovered new technologies to</p>	<p style="text-align: right;">103</p> <p>1 Have you seen this article before? 2 A. Uh-hmm. 3 Q. Are you familiar with it? 4 A. I am. 5 Q. This article was published in September 6 of 2022? 7 A. Yes. 8 Q. Excuse me. September 2012. I apologize. 9 A. Oh, right. 2012. I agree with you. 10 We're both wrong. 11 Q. Did this article demonstrate by 2012 new 12 technologies to deliver mRNA into cells? 13 A. This article was focused on the lipid 14 nanoparticle, as shown in Figure 1. 15 Q. And this article relates to what type of 16 mRNA? 17 A. So this would be a self-amplifying RNA. 18 Q. And yet this is the article that is 19 hyperlinked in the discussion of new technologies 20 to deliver mRNA. Right? 21 A. So let's keep in mind this article -- this 22 particular article was in 2022.</p>
<p style="text-align: right;">102</p> <p>1 deliver mRNA into cells"? 2 Q. Yeah. 3 A. Yes. 4 Q. Okay. Let's go to the article that is 5 hyperlinked there. 6 I'm going to hand you an exhibit which has 7 been marked as Exhibit 2021, which I'll represent 8 to you is the article that's hyperlinked in the 9 second hyperlink in this paragraph. 10 (Exhibit 2021, previously marked, is not 11 attached to the transcript.) 12 Q. The article that's hyperlinked is 13 "Nonviral delivery of self-amplifying RNA 14 vaccines." Do you see that? 15 MR. PRUSSIA: I'll object as no 16 foundation. 17 A. The second -- what is this? 18 Q. Hyperlink. 19 A. This one, the new technologies to deliver 20 mRNA. And it refers just to this article. Right? 21 Q. That is the article that is hyperlinked at 22 that phrase. Yes.</p>	<p style="text-align: right;">104</p> <p>1 And by 2022, this technology, while it 2 started and it's appropriate to always kind of 3 acknowledge the first article that -- the earliest 4 articles that use a particular formulation, was 5 initially used with a self-amplifying RNA. 6 By 2022, we knew that this particular type 7 of formulation would also work with mRNA. 8 So if I were to write this as a scientific 9 article, I would not just cite this one. I would 10 have cited additional articles that show the 11 progression of the use of LNPs not just with 12 self-amplifying RNA but with mRNA at later dates. 13 Q. This second sentence of Moderna 2021, the 14 second sentence of that abstract says, "Taking 15 advantage of the recent innovations in systemic 16 delivery of short interfering RNA (siRNA) using 17 lipid nanoparticles (LNPs), we developed a 18 self-amplifying RNA vaccine." 19 A. Which article are we looking at? 20 Q. Sorry. I apologize. We are at 21 Exhibit 2021, the Geall article. 22 A. Oh, still this one?</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 27 of 130

Conducted on August 2, 2024

<p>105</p> <p>1 Q. Yes.</p> <p>2 A. Got you.</p> <p>3 Q. And now I'm looking at the second sentence</p> <p>4 of the abstract.</p> <p>5 A. The second sentence of the abstract.</p> <p>6 Okay.</p> <p>7 Q. It says, "Taking advantage of the recent</p> <p>8 innovations in systemic delivery of short</p> <p>9 interfering RNA (siRNA) using lipid nanoparticles,</p> <p>10 (LNPs), we developed a self-amplifying RNA</p> <p>11 vaccine." Right?</p> <p>12 A. That's what it says.</p> <p>13 Q. You're familiar with lipid nanoparticles.</p> <p>14 Right?</p> <p>15 A. I am.</p> <p>16 Q. What are they?</p> <p>17 A. So they are fatty balls that encapsulate</p> <p>18 nucleic acids to facilitate both protection of the</p> <p>19 nucleic acid from degradation and then goes to the</p> <p>20 stability and to facilitate delivery of the RNA to</p> <p>21 cell.</p> <p>22 Q. So it's fair to say, isn't it, that lipid</p>	<p>107</p> <p>1 A. They were used to deliver self-amplifying</p> <p>2 RNA vaccines in this publication. Yes.</p> <p>3 Q. And this is the publication that's</p> <p>4 hyperlinked to the statement earlier made by you</p> <p>5 in your interview, saying that new technologies to</p> <p>6 deliver mRNA have been developed. Right?</p> <p>7 MR. PRUSSIA: Object to the form, no</p> <p>8 foundation.</p> <p>9 A. Again, I want to clarify that this is a</p> <p>10 particular reference. The article was written in</p> <p>11 2022. We knew by then that -- the LNPs in this</p> <p>12 article had by then been -- explored the mRNA</p> <p>13 vaccines.</p> <p>14 So I'm writing -- the interview was in the</p> <p>15 context of 2022 and what we knew by then, not what</p> <p>16 was occurring in 2012.</p> <p>17 And, as I mentioned, if I was to write</p> <p>18 this as a scientific article, I would have cited</p> <p>19 other articles.</p> <p>20 Q. Okay. Let's turn to the second page of</p> <p>21 the Geall article, page 14605. And I want to take</p> <p>22 your attention to Figure 1. And in particular,</p>
<p>106</p> <p>1 nanoparticles are for the purpose of delivering a</p> <p>2 payload, such as nucleic acids. Right?</p> <p>3 A. They are very commonly used for a lot of</p> <p>4 things, but also for nucleic acid vaccines and in</p> <p>5 particular RNA, anything that's RNA-based.</p> <p>6 Q. And lipid nanoparticles when delivering</p> <p>7 anything that's RNA-based, the purpose of the</p> <p>8 payload is to elicit an immune response. Right?</p> <p>9 A. Not always. It depends on what the RNA</p> <p>10 encodes and what your objective is.</p> <p>11 Q. Lipid nanoparticles -- lipid nanoparticles</p> <p>12 can be used to deliver mRNA. Right?</p> <p>13 A. They can.</p> <p>14 Q. And when were lipid nanoparticles first</p> <p>15 developed?</p> <p>16 A. The precise date, I don't know.</p> <p>17 Q. Okay. Lipid nanoparticles existed at</p> <p>18 least by September of 2012. Right?</p> <p>19 A. Yes.</p> <p>20 Q. And lipid nanoparticles had been used to</p> <p>21 deliver RNA vaccines by the date of this</p> <p>22 publication as well. Right?</p>	<p>108</p> <p>1 Figure 1B. Do you see that?</p> <p>2 A. Figure 1B, yes.</p> <p>3 Q. Figure 1B provides the four components of</p> <p>4 the lipid nanoparticle system. Right?</p> <p>5 A. If you're going to get into chemistry with</p> <p>6 me, I'm going to have to defer. That is not my</p> <p>7 area. But there are some components, and these</p> <p>8 components look recognizable as components of</p> <p>9 lipid nanoparticles.</p> <p>10 I'm not a chemist, so I'll defer. I know</p> <p>11 a different expert, Dr. Chan, was secured for</p> <p>12 compositions of lipid nanoparticles. So I will</p> <p>13 not be able to help you with anything beyond</p> <p>14 general knowledge.</p> <p>15 Q. I'll keep it at a high level. How about</p> <p>16 that?</p> <p>17 A. Keep it at a high level, yes.</p> <p>18 Q. The lipid nanoparticles used to deliver an</p> <p>19 RNA vaccine in this exhibit, Exhibit 2021,</p> <p>20 incorporated 10 percent of a zwitterionic lipid.</p> <p>21 Right?</p> <p>22 A. That's what it says.</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 28 of 130

Conducted on August 2, 2024

<p>109</p> <p>1 Q. Do you know whether zwitterionic lipid is</p> <p>2 the same thing as a neutral lipid?</p> <p>3 A. Again, I defer to Dr. Chan for those</p> <p>4 questions.</p> <p>5 Q. The lipid nanoparticles used to deliver an</p> <p>6 RNA vaccine in Exhibit 2022 -- 2021 incorporated</p> <p>7 40 percent cationic lipid. Right?</p> <p>8 A. I see that.</p> <p>9 Q. And if you'd look a few lines down under</p> <p>10 the heading "Results."</p> <p>11 A. Okay. It's right here.</p> <p>12 Q. Do you see that it says that the -- sorry;</p> <p>13 one moment -- that the lipid is ionizable cationic</p> <p>14 lipid? Do you see that?</p> <p>15 A. Which line?</p> <p>16 Q. Under "Results," about four lines down.</p> <p>17 A. The ionizable cationic lipid. Is that</p> <p>18 where you're at?</p> <p>19 Q. Yeah. Let me fix my question, if that's</p> <p>20 okay.</p> <p>21 We see at Figure 1B there is a mention of</p> <p>22 cationic lipid at 40 percent. Do you see that?</p>	<p>111</p> <p>1 Q. It references a cationic lipid in</p> <p>2 Figure 1B.</p> <p>3 A. So they're referring to studies --</p> <p>4 previous studies using that particular lipid.</p> <p>5 I'll just take a minute to read again this</p> <p>6 article.</p> <p>7 Q. Do you see in the results it's referring</p> <p>8 back to Figure 1B?</p> <p>9 Do you see the "Results" heading and then</p> <p>10 it says "Vaccine Formulation Characterization"?</p> <p>11 Do you see where I am?</p> <p>12 A. Are you looking at the figure legend?</p> <p>13 Q. I'm looking at the "Results" section.</p> <p>14 A. Yes, I do see "Vaccine Formulation</p> <p>15 Characterization."</p> <p>16 Q. And in the "Results" section, it's</p> <p>17 discussing "Proof of concept for LNP-facilitated</p> <p>18 delivery of self-amplifying RNA vaccines" . . .</p> <p>19 "using a subset of LNPs." Do you see that?</p> <p>20 A. Right.</p> <p>21 Q. And it references to Figure 1B?</p> <p>22 (Witness read from document)</p>
<p>110</p> <p>1 A. I see that.</p> <p>2 Q. And then if you go to the heading</p> <p>3 "Results," about four lines down it explains that</p> <p>4 the lipid is a -- excuse me -- an ionizable</p> <p>5 cationic lipid, which is DLinDMA. Do you see</p> <p>6 that?</p> <p>7 A. Yes, I see DLinDMA. That's where you're</p> <p>8 at?</p> <p>9 Q. Yes.</p> <p>10 It says the lipid nanoparticles used to</p> <p>11 deliver an RNA vaccine in Exhibit 2021</p> <p>12 incorporated 40 percent of an ionizable cationic</p> <p>13 lipid DLinDMA. Right?</p> <p>14 A. So the cationic lipid referred to in</p> <p>15 Figure 1 is the DLinDMA is what you're saying?</p> <p>16 Q. Correct.</p> <p>17 Am I right?</p> <p>18 A. So they reference 27, Reference Number 27.</p> <p>19 I'm just trying to understand the context</p> <p>20 a little bit. What they describe in Figure 1 as</p> <p>21 cationic lipid, is that matched up to or they just</p> <p>22 are describing that differently?</p>	<p>112</p> <p>1 A. Figure 1B, the ionizable cationic lipid --</p> <p>2 well, there's a disconnect between what's in the</p> <p>3 figure and the "Results" section where they call</p> <p>4 out cationic lipid in Figure B, but then they are</p> <p>5 talking about ionizable cationic lipid 1,2 or the</p> <p>6 DLinDMA in the "Results" section.</p> <p>7 Q. Do you see in Figure 1B that they -- the</p> <p>8 lipid nanoparticles used to deliver RNA vaccine in</p> <p>9 Exhibit 2021 incorporated 48 percent cholesterol?</p> <p>10 A. In Figure 1B it says 48 percent</p> <p>11 cholesterol.</p> <p>12 Q. And the lipid nanoparticles used to</p> <p>13 deliver an RNA vaccine in Exhibit 2021</p> <p>14 incorporated 2 percent PEGylated lipid. Right?</p> <p>15 A. So Figure 1B says PEGylated lipid at</p> <p>16 2 percent.</p> <p>17 Q. Okay. On the right hand column of that</p> <p>18 same page that we've been discussing, about four</p> <p>19 lines down it reads, "Agarose gel electrophoresis</p> <p>20 showed that RNA integrity was maintained during</p> <p>21 formulation and that the LNPs protected the RNA</p> <p>22 from degradation by RNase." Do you see that?</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 29 of 130

Conducted on August 2, 2024

<p>113</p> <p>1 A. So I see that they say six LNP 2 formulations. There is a supplement on Table 1 3 which is not included in the article. And then 4 they would be referring to that. This particular 5 context of the results section is referring to the 6 six in Table S1. 7 And then I'll have to check with 8 Figure 1C. 9 Q. Maybe I can just short-circuit some of 10 this. Let me take a giant step back. 11 It's talking here about LNPs protecting 12 RNA from degradation by RNase. Right? 13 A. In this paper? 14 Q. In this paper. 15 A. So Figure 1C -- let me just read the -- 16 Figure 1C might be where they're talking about 17 that. 18 Q. Let me just ask my question a different 19 way. 20 What is RNase? Do you know? 21 A. RNase is an agent that's used to degrade 22 RNA.</p>	<p>115</p> <p>1 sentences later. Pardon me. 2 A. Okay. Where are you looking? 3 Q. It's about eight lines down, in the same 4 paragraph. 5 A. What is the start of the sentence? 6 Q. It starts with the word "Encapsulation." 7 A. I see that. And let me just read the rest 8 of it. 9 Q. Let me just ask my question outside the 10 context of the article. Maybe that will be 11 easier. 12 Do you have any understanding as to how 13 lipid nanoparticles promote delivery of RNA into 14 muscle? 15 A. You mean the chemistry or just the big 16 picture? 17 Q. Just big picture. What's your big-picture 18 understanding? 19 A. Of how LNPs would deliver RNA into a cell? 20 Q. Yes. 21 A. The lipid nanoparticles include a lipid 22 bilayer surrounding them.</p>
<p>114</p> <p>1 Q. And is protection from degradation by 2 RNase important for an RNA vaccine? 3 A. That's a tool that researchers will use to 4 demonstrate that RNA is either degraded or not 5 degraded, depending upon what the question is. 6 Q. And is nonreplicating mRNA also degraded 7 by RNase? 8 A. So all RNA can be -- types of RNA forms 9 can be degraded by RNase. 10 Q. So a protection from degradation by RNase 11 would be important for all RNA types. Correct? 12 A. Yeah. If you want to demonstrate if your 13 RNA is protected, that would be a tool to use, one 14 tool to use. 15 Q. The next sentence in this article, it 16 states, "Encapsulation was also required for 17 efficient delivery of functional RNA into muscle." 18 Do you see that? 19 A. Where are you looking? 20 Q. So we were talking earlier about the 21 sentence that talked about RNase. 22 It's just the very next sentence or two</p>	<p>116</p> <p>1 So that particular lipid bubble protects 2 the RNA from being degraded. So once it gets 3 injected in the body, the RNases that are 4 naturally found in our body are not going to 5 degrade the RNA. 6 But it also has a second function where it 7 can actually fuse with the cell's membrane and 8 then deposit the RNA into the cytoplasm of the 9 cell. 10 Q. Is it fair to say that that function is 11 the same regardless of whether you're delivering 12 self-amplifying RNA or some other type of RNA? 13 MR. PRUSSIA: Object to the form. 14 A. Does a lipid nanoparticle work the same 15 regardless of what? Could you reask that 16 question? 17 Q. Does a lipid nanoparticle work the same 18 regardless of whether you're delivering a 19 self-amplifying RNA or some other type of RNA? 20 A. That's a theory. 21 Q. This article that we're discussing, the 22 Geall article, showed the efficient delivery of</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 30 of 130

Conducted on August 2, 2024

<p style="text-align: right;">117</p> <p>1 functional RNA into methyl could be accomplished</p> <p>2 by using -- I'm looking at Figure 1B now --</p> <p>3 10 percent zwitterionic lipid. Correct?</p> <p>4 A. Yes, that's what it says.</p> <p>5 Q. 40 percent cationic lipid?</p> <p>6 A. That's what it says.</p> <p>7 Q. 48 percent cholesterol?</p> <p>8 A. That's what it says.</p> <p>9 Q. And 2 percent PEGylated lipid. Correct?</p> <p>10 A. That's what it says. Yes.</p> <p>11 Q. Okay.</p> <p>12 A. I do want to note here -- and because the</p> <p>13 table is not there -- that there were six</p> <p>14 different LNP RNA formulations used in the study.</p> <p>15 So without really looking at the Table S1,</p> <p>16 reviewing the article again, I just want to be</p> <p>17 clear that I am not entirely clear that all of the</p> <p>18 six formulations that they're testing are actually</p> <p>19 what's described in B or if there might be some</p> <p>20 variation on that.</p> <p>21 Q. Okay. Towards the bottom of page 14605,</p> <p>22 same page that we're on, there's a heading at the</p>	<p style="text-align: right;">119</p> <p>1 A. So when we talk about a conserved target,</p> <p>2 that means that even if there are some variations</p> <p>3 in the RSV sequence, that particular F protein</p> <p>4 remains fairly conserved, particularly the</p> <p>5 epitopes that are targeted by the neutralizing</p> <p>6 antibody.</p> <p>7 Q. Are you familiar with any of the</p> <p>8 FDA-approved vaccines against RSV?</p> <p>9 A. Somewhat. Not fully familiar, no.</p> <p>10 Q. Are you aware of whether they're built on</p> <p>11 the RSV F protein?</p> <p>12 A. So I do not recall. I think so.</p> <p>13 Q. Okay.</p> <p>14 A. I'm not sure.</p> <p>15 Q. While we're on the topic of</p> <p>16 self-amplifying RNA or self-replicating RNA, saRNA</p> <p>17 would be administered at a different dose than</p> <p>18 nonself-replicating RNA. Is that fair?</p> <p>19 A. It depends.</p> <p>20 Q. Is it fair to say that it's typically</p> <p>21 administered at a different dose?</p> <p>22 A. So regardless of what vaccine that you</p>
<p style="text-align: right;">118</p> <p>1 bottom of the right-hand column that begins with</p> <p>2 "Immunogenicity." Do you see that?</p> <p>3 A. Yes.</p> <p>4 Q. Under that heading it says, "To test the</p> <p>5 LNP/RNA formulation as a vaccine, self-amplifying</p> <p>6 RNAs encoding viral antigens were evaluated for</p> <p>7 immunogenicity in mice. The F protein of RSV is a</p> <p>8 conserved target of neutralizing antibodies and a</p> <p>9 promising antigen for RSV antigen development."</p> <p>10 Do you see that?</p> <p>11 A. I do.</p> <p>12 Q. Do you have any familiarity with RSV?</p> <p>13 A. I do.</p> <p>14 Q. What is your familiarity?</p> <p>15 A. It's respiratory syncytial virus. And it</p> <p>16 causes respiratory infections, particularly in</p> <p>17 young children and the elderly. And there was</p> <p>18 recently a successful vaccine clinical trial and</p> <p>19 vaccine licensed for protection against RSV.</p> <p>20 Q. And what does it mean that "The F protein</p> <p>21 of RSV is a conserved target of neutralizing</p> <p>22 antibodies"?</p>	<p style="text-align: right;">120</p> <p>1 have, you have to -- multiple things can influence</p> <p>2 a dose. So that can be the immunogen that you</p> <p>3 use.</p> <p>4 Some immunogens are more immunogenic than</p> <p>5 others. That can be the platform that you use.</p> <p>6 Some work in lower doses. Some work in higher</p> <p>7 doses. So multiple variables can influence the</p> <p>8 dose that you use.</p> <p>9 So when you have a given vaccine, you have</p> <p>10 to do the dose escalation curve to actually</p> <p>11 determine what dosing range or what dose is going</p> <p>12 to give you sufficient immune response to provide</p> <p>13 protection.</p> <p>14 You've got that additional variable. What</p> <p>15 do you actually need in terms of immune response</p> <p>16 to get to a level of protection?</p> <p>17 So when we want to know whether if it's</p> <p>18 DNA or RNA, self-amplifying RNA or mRNA, what dose</p> <p>19 is going to be optimal, it has to be tested, and</p> <p>20 we can't just conclusively say that the dose of</p> <p>21 one modality is going to automatically always be</p> <p>22 higher or lower than the other.</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

Conducted on August 2, 2024

<p>121</p> <p>1 Q. Okay. Fair. So if I put it a different</p> <p>2 way, a POSA wouldn't look to literature on</p> <p>3 self-amplifying mRNA to determine dosage levels of</p> <p>4 nonamplifying RNA. Is that fair?</p> <p>5 A. They might look to it as a starting block</p> <p>6 to find a range, but they would still have to do</p> <p>7 their own experiments to determine a precise dose.</p> <p>8 Q. A POSA wouldn't primarily consult</p> <p>9 nonamplifying RNA literature when determining</p> <p>10 dosing for self-amplifying RNA. Right?</p> <p>11 A. So again, you have to test it yourself. A</p> <p>12 POSA might look into the literature to identify,</p> <p>13 say, dosing range because you would just -- you</p> <p>14 can't go to infinite doses. You want to kind of</p> <p>15 get an idea.</p> <p>16 If there was no other studies, for</p> <p>17 example, if we were to do an experiment with a</p> <p>18 given vaccine with a given immunogen and the only</p> <p>19 references out there, self-amplifying RNA, the</p> <p>20 only reference out there was one for, say, an</p> <p>21 mRNA, I might start there to get an idea of maybe</p> <p>22 kind of a range of doses to start with.</p>	<p>123</p> <p>1 A. So it says when it was filed and it has a</p> <p>2 number of -- the priority date it was filed,</p> <p>3 October 22, 2015.</p> <p>4 Q. Do you have an understanding of what the</p> <p>5 priority date is for the '600 patent?</p> <p>6 A. I do.</p> <p>7 Q. And what is it?</p> <p>8 A. So that would have been the original</p> <p>9 filing of a provisional patent application that</p> <p>10 would have had the initial invention. And then</p> <p>11 over time if additional revisions are required,</p> <p>12 then there will be additional things added to it.</p> <p>13 Q. And what's the priority date for the '600</p> <p>14 patent?</p> <p>15 A. I'm reading filed on October 22, 2015.</p> <p>16 Q. You understand that the '600 patent and</p> <p>17 the '127 patents share a specification. Correct?</p> <p>18 A. Could you elaborate a little bit what you</p> <p>19 mean?</p> <p>20 Q. Do you have an understanding as to the</p> <p>21 similarities between the specification I'm talking</p> <p>22 about, the meat of the actual patents themselves?</p>
<p>122</p> <p>1 But I'd still have to do the experiments</p> <p>2 with the self-amplifying RNA to arrive at the</p> <p>3 optimal dose for that.</p> <p>4 Q. Okay. We talked earlier about the fact</p> <p>5 that these proceedings involve two different</p> <p>6 patents. Right? The '600 patent and the '127</p> <p>7 patent?</p> <p>8 A. Uh-hmm.</p> <p>9 Q. Did you review these patents in</p> <p>10 preparation for your deposition today?</p> <p>11 A. I did.</p> <p>12 Q. I'm going to give you, actually, both the</p> <p>13 '600 patent, which has been premarked, and the</p> <p>14 '127 patent, which has also been premarked.</p> <p>15 (Exhibits 1001 ['127] and 1001 ['600],</p> <p>16 previously marked, are not attached to the</p> <p>17 transcript.)</p> <p>18 Q. Okay. Let's look first at the '600</p> <p>19 patent. This patent application was filed</p> <p>20 February 28th, 2020. Right?</p> <p>21 A. I'm trying to just --</p> <p>22 Q. It's on the front page here.</p>	<p>124</p> <p>1 A. Right. When you say "specification," you</p> <p>2 mean the main -- the claims or --</p> <p>3 Q. When I say "specification" -- actually,</p> <p>4 let me ask it a different way.</p> <p>5 Do you have any understanding as to what</p> <p>6 specification of a patent is?</p> <p>7 A. I'm not a patent attorney. I have an idea</p> <p>8 of what goes -- because I have been an inventor on</p> <p>9 multiple patents myself, so I have some ideas.</p> <p>10 But if you start to get into the legal lingo,</p> <p>11 you'll have to probably clarify. I think I know,</p> <p>12 but I'd rather hear from the expert.</p> <p>13 Q. Do you have an understanding as to the</p> <p>14 similarities between what's disclosed outside of</p> <p>15 the claims? So putting aside the claims.</p> <p>16 A. Right. Okay. Yeah.</p> <p>17 Q. Do you have an understanding of what's</p> <p>18 disclosed in the '600 and the '127 patents,</p> <p>19 putting aside the claims?</p> <p>20 A. Right. Yeah.</p> <p>21 Q. You do?</p> <p>22 A. What's, like, the examples and the data</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 32 of 130

Conducted on August 2, 2024

<p>125</p> <p>1 that's presented? Yeah.</p> <p>2 Q. Do you have any understanding as to</p> <p>3 whether the '600 patent and the '127 patent share</p> <p>4 any similarities in that disclosure?</p> <p>5 A. They have some similarities. Yeah.</p> <p>6 Q. Do you have an understanding that they</p> <p>7 share a specification outside of the claims?</p> <p>8 A. Again, define "specification."</p> <p>9 Q. Everything that is before the claims.</p> <p>10 A. Everything before the claims. Yes.</p> <p>11 Q. That they share --</p> <p>12 A. Basically have a lot of the same</p> <p>13 information is what you're saying?</p> <p>14 Q. I'm asking whether you have that</p> <p>15 understanding.</p> <p>16 A. Yeah, they have a lot of the similar</p> <p>17 information in there.</p> <p>18 Q. Let's turn to Column 3 of the '600 patent,</p> <p>19 at line 4 it reads, "Severe acute respiratory</p> <p>20 syndrome (SARS) emerged in China in 2002 and</p> <p>21 spread to other countries before being brought</p> <p>22 under control. Because of a concern for</p>	<p>127</p> <p>1 And so by 2015, actually the most</p> <p>2 enthusiasm was about Zika because there was a new</p> <p>3 Zika outbreak at that point, less about</p> <p>4 coronavirus.</p> <p>5 So I have even a colleague, David Beiser</p> <p>6 at the University of Washington, who had just</p> <p>7 started his career in 2017 there, and he was</p> <p>8 lamenting that he was having a hard time getting</p> <p>9 funding. And he solely studied coronaviruses</p> <p>10 because nobody cared about them anymore.</p> <p>11 Q. Column 3 of the '600 patent, under the</p> <p>12 heading "Summary" the patent states, "Provided</p> <p>13 herein are ribonucleic acid (RNA) vaccines that</p> <p>14 build on the knowledge that RNA" --</p> <p>15 A. I'm sorry. I'm actually not where you're</p> <p>16 at.</p> <p>17 Q. I'll slow down. I apologize. Do you see</p> <p>18 Column 3?</p> <p>19 A. Column 3.</p> <p>20 Q. The heading "Summary"?</p> <p>21 A. Yes.</p> <p>22 Q. I'm just reading that first sentence after</p>
<p>126</p> <p>1 reemergence or deliberate release of the SARS</p> <p>2 coronavirus, vaccine development was initiated."</p> <p>3 You see that. Right?</p> <p>4 A. Yes.</p> <p>5 Q. Do you agree that as of 2015 there</p> <p>6 remained a latent need for a betacoronavirus</p> <p>7 vaccine to be ready in the event of a future</p> <p>8 pandemic, even though the SARS and MERS outbreaks</p> <p>9 had been controlled?</p> <p>10 A. There was still a recognized need for a</p> <p>11 coronavirus vaccine, although by 2015 a lot of</p> <p>12 that enthusiasm had declined simply because</p> <p>13 once -- this is kind of the way the field is. You</p> <p>14 get sort of an outbreak and everybody beehives</p> <p>15 towards it and tries to solve the problem.</p> <p>16 And then it goes away, and people's</p> <p>17 attention turns to the next thing, such as a MERS</p> <p>18 outbreak, such as a Zika outbreak. And you see</p> <p>19 that wax and wane particularly in the field. And</p> <p>20 because that's -- honestly, that's where funding</p> <p>21 is driven, so people work on different sorts of</p> <p>22 things.</p>	<p>128</p> <p>1 "Summary."</p> <p>2 It says "Provided herein are ribonucleic</p> <p>3 acid (RNA) vaccines that build on the knowledge</p> <p>4 that RNA, (e.g., messenger RNA (mRNA)) can safely</p> <p>5 direct the body's cellular machinery to produce</p> <p>6 nearly any protein of interest, from native</p> <p>7 proteins to antibodies and other entirely novel</p> <p>8 protein constructs that have therapeutic activity</p> <p>9 inside and outside of cells." Do you see that?</p> <p>10 A. I see that.</p> <p>11 Q. You would agree with me, wouldn't you,</p> <p>12 that the inventors on the '600 patent were not the</p> <p>13 first to discover RNA vaccines. Right?</p> <p>14 A. So the original discovery of the idea of</p> <p>15 RNA vaccines actually started in the 1990s,</p> <p>16 although that was not successful.</p> <p>17 So the conceptualization of the idea of</p> <p>18 RNA vaccines and the first experiments to</p> <p>19 determine could you inject RNA into the body and</p> <p>20 would that actually result in an immune response</p> <p>21 started in the 1990s but was not very successful.</p> <p>22 Q. Is it fair to say that the inventors of</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 33 of 130

Conducted on August 2, 2024

<p style="text-align: right;">129</p> <p>1 the '600 patent built upon the knowledge that was 2 already gained in the -- or started in the 1990s? 3 A. So most of the -- yeah, the field pretty 4 much moved forward from beginning in the 1990s, 5 but I would say the majority of what was built on 6 was on DNA vaccines. 7 There was decades of research in DNA 8 vaccines early in the 1990s. The mRNA vaccines 9 didn't work for various reasons. We were seeing 10 more success with DNA vaccines. 11 And that took off through the 1990s and 12 2000s all the way up to even I would say in 2015 13 DNA vaccines were still much more popular, much 14 more effectively used, more routinely used in 15 research than mRNA vaccines. 16 Self-amplifying RNA vaccines started 17 coming into the forefront in the late '90s as 18 well, and they were still of considerable interest 19 in 2015. But by 2015, I would not say that mRNA 20 vaccines were a particular priority. 21 Q. You do see here that at Column 3, the 22 sentence we just read, the inventors when they</p>	<p style="text-align: right;">131</p> <p>1 safely direct the body's cellular machinery to 2 produce nearly any protein of interest? 3 A. Yeah. I would say that a POSA could 4 expect that there was technology and methods out 5 there to show that you could deliver mRNA and 6 produce a protein. Whether it was of therapeutic 7 levels needed of that, that was not the case at 8 the time. 9 There was still some work that needed to 10 be done to get mRNA vaccines to the point that 11 they could actually express a protein at levels 12 that would be useful. 13 Q. The '600 patent doesn't specifically 14 discuss SARS-CoV-2, does it? 15 A. No, it does not. It discusses 16 betacoronaviruses of which SARS-CoV-2 is one of 17 them. 18 Q. And although it claims priority to 19 October 2015, the '600 patent couldn't discuss 20 SARS-CoV-2 because it hadn't emerged yet. Right? 21 A. SARS-CoV-2 did not emerge until 2020. 22 Q. Let's go to Column 213. At Columns 213</p>
<p style="text-align: right;">130</p> <p>1 applied for this patent included in their 2 application a statement that "RNA (e.g., messenger 3 RNA (mRNA)) can safely direct the body's cellular 4 machinery to produce nearly any protein of 5 interest." Do you see that? 6 A. Right. So they're referring to 7 therapeutic potential that was fairly well 8 established, the concept of using mRNA for 9 therapeutic purposes. Yes. 10 Q. So the concept of using mRNA for 11 therapeutic purposes was well established by 12 October 2015? 13 A. So it was -- there was -- particularly the 14 work that we were talking about before by Karikó 15 and Weissman, where they were able to demonstrate 16 increased expression of protein from an mRNA and 17 dampening and loss of immunogenicity, were things 18 that were known by 2015. 19 Q. So with that background and knowledge, is 20 it fair to say that a person of ordinary skill in 21 the art would reasonably expect that 22 administration of mRNA encoding a protein would</p>	<p style="text-align: right;">132</p> <p>1 and 214, there are Examples 23 and 24. Correct? 2 A. Example 22 and -- 22 or 23? 3 Q. I may have misspoke. I meant Example 23 4 and 24. 5 A. 23, the first CoV vaccine immunogenicity 6 in mice and New Zealand white rabbits. That's 7 what you're referring to? 8 Q. Correct. Are these the only two working 9 examples of an mRNA vaccine against a 10 betacoronavirus? 11 A. So this is -- the MERS-CoV was the 12 examples for a betacoronavirus in this project. 13 Yes. In this patent. 14 Q. At line 60 under the heading "Example 15 23" -- do you see where I am? 16 A. Yes. 17 Q. -- line 60, right under that heading it 18 says, "The instant study was designed to test the 19 immunogenicity in mice of candidate MERS-CoV 20 vaccines comprising an mRNA polynucleotide 21 encoding the full-length spike protein, or the S2 22 subunit of the spike protein obtained from</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 34 of 130

Conducted on August 2, 2024

<p>133</p> <p>1 MERS-CoV." Do you see that?</p> <p>2 A. Yes.</p> <p>3 Q. What strain of MERS-CoV did the vaccine of</p> <p>4 Example 23 encode?</p> <p>5 A. I would have to find that again. I don't</p> <p>6 remember without looking at it. We can take the</p> <p>7 time for me to look it up.</p> <p>8 Q. Multiple different nucleotide sequences</p> <p>9 can encode for a given protein. Right?</p> <p>10 A. Could you elaborate more specifically</p> <p>11 about which protein you're referring to?</p> <p>12 Q. It's a general, fair statement. Correct?</p> <p>13 A. It's a general statement. For a viral</p> <p>14 protein, you mean?</p> <p>15 Q. Any protein.</p> <p>16 A. Yeah, you can have different sequences</p> <p>17 because different sequences -- different amino</p> <p>18 acids can be substituted and still result in the</p> <p>19 same structural protein.</p> <p>20 Q. How many unique nucleotide sequences can</p> <p>21 encode for a given MERS-CoV spike protein?</p> <p>22 A. How many nucleotide sequences can encode</p>	<p>135</p> <p>1 actually included the 5' cap.</p> <p>2 Q. Did it include a 5' ETR?</p> <p>3 A. It was an untranslated region.</p> <p>4 Q. Do you know which one?</p> <p>5 A. I can't get to the specifics there.</p> <p>6 Q. Did it include a poly-A tail?</p> <p>7 A. It includes a poly-A tail.</p> <p>8 Q. Do you know which poly-A tail?</p> <p>9 A. Like I say, I can't get to the specifics</p> <p>10 of the exact sequences there without looking it</p> <p>11 up.</p> <p>12 Q. Are you able to provide any of the details</p> <p>13 in, for example, 23 or 24?</p> <p>14 A. If I were given time to look it up, I'd be</p> <p>15 able to provide you with that information.</p> <p>16 Q. Let's move on.</p> <p>17 Examples 23 and 24 don't include the lipid</p> <p>18 nanoparticle formulations that were used.</p> <p>19 Correct?</p> <p>20 A. I'm going to take a look at the figures</p> <p>21 because the figure legends had additional</p> <p>22 information on there.</p>
<p>134</p> <p>1 for a MERS? I don't know. A spike protein is</p> <p>2 about 1,300 amino acids long, in general. I don't</p> <p>3 know exactly.</p> <p>4 Q. Fair to say a lot?</p> <p>5 A. Yeah. Quite a few.</p> <p>6 Q. Does Example 23 specify which nucleotide</p> <p>7 sequence the coding region of the vaccine</p> <p>8 contains?</p> <p>9 A. Example 23 refers to the MERS -- MERS-CoV</p> <p>10 and then it provides tables of sequences for the</p> <p>11 spike protein for MERS-CoV.</p> <p>12 Q. Do you know if the example of 23 includes</p> <p>13 a 5' cap?</p> <p>14 A. The example in 23 includes the 5' cap.</p> <p>15 Q. Do you know which 5' cap?</p> <p>16 A. I would have to look back at the specifics</p> <p>17 on that.</p> <p>18 Q. How do you know it includes the 5' cap?</p> <p>19 A. Well, for mRNA we'd have to have the 5'</p> <p>20 cap.</p> <p>21 Q. Are you just assuming?</p> <p>22 A. No. I read that in there that they</p>	<p>136</p> <p>1 Q. I can actually help you out. Take a look</p> <p>2 at Column 212 under the heading "Example 20."</p> <p>3 Line 47, it says, "In experiments where a</p> <p>4 lipid nanoparticle (LNP) formulation is used, the</p> <p>5 formulation may include a cationic lipid,</p> <p>6 non-cationic lipid, PEG lipid and structural lipid</p> <p>7 in the ratios 50:10:1.5:38.5. The cationic lipid</p> <p>8 is DLin-KC2-DMA (50 mol %) or DLin-MC3-DMA</p> <p>9 (50 mol %), the non-cationic lipid is DSPC</p> <p>10 (10 mol %), the PEG lipid is PEG-DOMG (1.5 mol %)</p> <p>11 and the structural lipid is cholesterol</p> <p>12 (38.5 mol %)."</p> <p>13 Do you see that?</p> <p>14 A. I see that.</p> <p>15 Q. Is it fair to say, then, that the mRNA</p> <p>16 vaccines of the examples that we just looked at in</p> <p>17 Example 23 and 24 use one of two lipid</p> <p>18 nanoparticle formulations?</p> <p>19 MR. PRUSSIA: I'll just object to the form</p> <p>20 because you left out "for example."</p> <p>21 A. Do you want to repeat that question with</p> <p>22 the "for example"?</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 35 of 130

Conducted on August 2, 2024

<p>137</p> <p>1 Q. Is it fair to say that the mRNA vaccines</p> <p>2 of the examples that we just looked at in</p> <p>3 Example 23 and 24 use one of two lipid</p> <p>4 nanoparticle formulations?</p> <p>5 A. Let me just check that.</p> <p>6 I'm looking at a number of different</p> <p>7 variables here.</p> <p>8 (Witness read from document)</p> <p>9 A. I guess I can't comment on that just</p> <p>10 because I'm not the chemist person. I don't</p> <p>11 understand to some extent some of the -- how they</p> <p>12 actually are terming some of those things and</p> <p>13 whether that refers to two variables or not when</p> <p>14 talking about the cationic lipid component.</p> <p>15 So I guess I will defer on that question.</p> <p>16 I would have to study that some more.</p> <p>17 Q. Let's just try to do it at a high level</p> <p>18 and see if that works. Okay?</p> <p>19 The mRNA of the vaccines included in</p> <p>20 Examples 23 and 24 used one of two lipid</p> <p>21 nanoparticle formulations, which I can point you</p> <p>22 to here in Column 212.</p>	<p>139</p> <p>1 is used, the formulation is provided. Do you see</p> <p>2 that?</p> <p>3 A. This entire Example 20 is referring to the</p> <p>4 rabbit study. So then this context of these two</p> <p>5 lipid nanoparticle formulations that are described</p> <p>6 would be specific to the rabbit study.</p> <p>7 Q. Specific to Example 23 and 24?</p> <p>8 A. I don't see that in -- I don't see how</p> <p>9 that's read here because they are talking about</p> <p>10 the instant study is designed to test</p> <p>11 immunogenicity in rabbits. And then they talk</p> <p>12 about the conditions of immunizing the rabbits.</p> <p>13 Q. Okay. We'll do it that way. Let's focus</p> <p>14 for a moment on the disclosure of the cationic</p> <p>15 lipid or lipids that are discussed in Column 212.</p> <p>16 At line 50, it says the cationic lipid is</p> <p>17 DLin-KC2-DMA or DLin-MC3-DMA. Correct?</p> <p>18 A. Those are the -- that's what it says.</p> <p>19 Q. So there are two options for the cationic</p> <p>20 lipid?</p> <p>21 A. I see that.</p> <p>22 Q. For the noncationic lipid, it's DSPC at</p>
<p>138</p> <p>1 One is 50 mol % DLin-KC-DMA, 10 mol %</p> <p>2 DSPC, 1.5 mol % PEG-DOMG, and 38.5 mol %</p> <p>3 cholesterol.</p> <p>4 Do you see that? It's right here.</p> <p>5 A. Would you point that out to me?</p> <p>6 Q. It's right here where we just discussed.</p> <p>7 A. What page are you on?</p> <p>8 Q. Column 212.</p> <p>9 A. 212, okay. Oh, right, right. Okay. This</p> <p>10 is where we're talking about in terms of</p> <p>11 betacoronavirus . . .</p> <p>12 Prior to that, they're talking about the</p> <p>13 rabbit study. So this would be specific to the</p> <p>14 rabbit study that we're referring to.</p> <p>15 Q. I'm referring to the Example 20, the</p> <p>16 heading "Betacoronavirus Immunogenicity Study."</p> <p>17 And it makes clear under that heading that the</p> <p>18 experiments include certain lipid nanoparticles.</p> <p>19 A. Right. And it makes clear this is the</p> <p>20 rabbit study specifically.</p> <p>21 Q. It makes clear in Column 212 that in</p> <p>22 experiments where lipid nanoparticle formulation</p>	<p>140</p> <p>1 10 mol %. Correct?</p> <p>2 A. I see that.</p> <p>3 Q. And the PEG lipid is PEG-DOMG 1.5 mol %.</p> <p>4 Do you see that?</p> <p>5 A. Yes.</p> <p>6 Q. And the structural lipid is cholesterol at</p> <p>7 38.5 %. Do you see that?</p> <p>8 A. Right. And then prior to that it's the</p> <p>9 formulation may include a big picture, cationic</p> <p>10 lipid, noncationic lipid, PEG lipid, and</p> <p>11 structural lipid. So it's talking about all those</p> <p>12 in the ratios of 50:10:1.5:38.5.</p> <p>13 And I think that is what it's referring to</p> <p>14 then below. Got you.</p> <p>15 Q. Do you have any understanding that the</p> <p>16 inventors of this '600 patent actually discovered</p> <p>17 those lipid nanoparticle formulations that we just</p> <p>18 discussed?</p> <p>19 A. So --</p> <p>20 MR. PRUSSIA: Hold on, hold on. I'll just</p> <p>21 object to the form. Object to the form.</p> <p>22 Go ahead.</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 36 of 130

Conducted on August 2, 2024

<p>141</p> <p>1 A. That's not what I was really asked to</p> <p>2 evaluate for my declaration in terms of the source</p> <p>3 of -- and I, again, would defer to the other</p> <p>4 expert that was brought in to discuss chemical</p> <p>5 formulations.</p> <p>6 Q. Okay. Could we look at Example 23 and 24.</p> <p>7 Both state that they encode the full-length spike</p> <p>8 protein or the S2 subunit of a spike protein</p> <p>9 obtained from MERS-CoV.</p> <p>10 A. That's what it says.</p> <p>11 Q. By 2015, was the full-length MERS-CoV</p> <p>12 spike protein a known vaccine antigen?</p> <p>13 A. The sequence was known.</p> <p>14 Q. Are you aware of any vaccines designed to</p> <p>15 express the MERS-CoV spike protein?</p> <p>16 A. Any vaccine designed to express the</p> <p>17 MERS --</p> <p>18 Q. -- CoV spike protein.</p> <p>19 A. You mean among nucleic acids or just any?</p> <p>20 Q. In general.</p> <p>21 A. There were other MERS-CoV vaccines that</p> <p>22 were developed as well or experimental vaccines.</p>	<p>143</p> <p>1 development. Correct?</p> <p>2 I missed a word. Let me say it again.</p> <p>3 The abstract states that the emergence of</p> <p>4 Middle East respiratory syndrome coronavirus or</p> <p>5 MERS-CoV as a cause of severe respiratory disease</p> <p>6 highlights the need for effective approaches to</p> <p>7 CoV vaccine development. Right?</p> <p>8 A. So yeah. The title evaluation candidate</p> <p>9 vaccine approaches for MERS-CoV.</p> <p>10 What are you looking at here? Which part?</p> <p>11 Q. The first sentence of the abstract.</p> <p>12 A. The emergence of Middle Eastern</p> <p>13 respiratory -- okay. Got you.</p> <p>14 Q. And that highlighted the need for</p> <p>15 effective approaches to coronavirus vaccine</p> <p>16 development. Correct?</p> <p>17 A. So that's what it states.</p> <p>18 Q. And that's true as of 2015. Correct?</p> <p>19 A. In 2015, MERS was still having occasional</p> <p>20 outbreaks. And while it wasn't highly prevalent,</p> <p>21 maybe a few hundred people would become infected</p> <p>22 at a high rate of mortality.</p>
<p>142</p> <p>1 (Fuller Exhibit 1101 was marked for</p> <p>2 identification and is not attached to the</p> <p>3 transcript.)</p> <p>4 Q. The court reporter has just handed you</p> <p>5 what's been marked as Exhibit 1101.</p> <p>6 MR. PRUSSIA: She's not an author, so I'll</p> <p>7 object to this as outside the record.</p> <p>8 Go ahead.</p> <p>9 Q. Are you familiar with this article?</p> <p>10 A. I've seen it before. I have not read it</p> <p>11 before in completion. I've seen some of the data</p> <p>12 presented before conferences, but I can't remember</p> <p>13 if I've read the entire article.</p> <p>14 Q. Are you familiar with any of the authors</p> <p>15 on the article?</p> <p>16 A. I know Barney. I know John Mascola,</p> <p>17 Barney Graham, some of the main authors there.</p> <p>18 I'm familiar with their work. Yes.</p> <p>19 Q. The abstract states that the emergence of</p> <p>20 Middle East respiratory syndrome coronavirus or</p> <p>21 MERS-CoV as a cause of severe respiratory disease</p> <p>22 highlights the effective approaches to CoV vaccine</p>	<p>144</p> <p>1 And there was always the concern in the</p> <p>2 back of people's mind if that could ever emerge as</p> <p>3 a pandemic, then it's something we might want to</p> <p>4 be prepared for.</p> <p>5 Q. And the second sentence in that abstract</p> <p>6 starts with "Efforts." Do you see it?</p> <p>7 A. I see that.</p> <p>8 Q. "Efforts focused solely on the receptor</p> <p>9 binding domain of the viral spike or S</p> <p>10 glycoprotein may not optimize neutralizing</p> <p>11 antibody or NAb responses." Do you see that?</p> <p>12 A. I see that.</p> <p>13 Q. Why would a scientist want a vaccine to</p> <p>14 induce neutralizing antibody response?</p> <p>15 A. So in vaccines in general, the majority of</p> <p>16 the mechanism of protection for most vaccines is</p> <p>17 through antibody response because antibodies can</p> <p>18 function to prevent the infection. And so that</p> <p>19 was -- often is our first line of defense.</p> <p>20 Q. So neutralizing antibody response is a</p> <p>21 desired result of administering a given vaccine</p> <p>22 construct. Correct?</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 37 of 130

Conducted on August 2, 2024

<p>145</p> <p>1 A. Neutralizing antibody is generally an</p> <p>2 important target for a vaccine, but it's not the</p> <p>3 only one.</p> <p>4 Q. Other than just administrating the</p> <p>5 vaccine, there is no other step that needs to be</p> <p>6 taken to induce a neutralizing antibody response.</p> <p>7 Is that correct?</p> <p>8 MR. PRUSSIA: Object to the form of the</p> <p>9 question.</p> <p>10 A. Other than just introducing the vaccine?</p> <p>11 Well, you have to, of course, as we talked about,</p> <p>12 make sure that your vaccine has been validated</p> <p>13 before you can introduce that into an animal.</p> <p>14 Q. Sure. Going back to the article, it says,</p> <p>15 "Here we show that immunogens based on full-length</p> <p>16 S DNA and S1 subunit protein elicit robust</p> <p>17 serum-neutralizing activity against several</p> <p>18 MERS-CoV strains in mice and non-human primates."</p> <p>19 Right?</p> <p>20 A. So this is a DNA vaccine, and they are</p> <p>21 talking about -- yes, I see that.</p> <p>22 Q. So it describes a DNA vaccine encoding the</p>	<p>147</p> <p>1 The definition of a vaccine composition is</p> <p>2 the form that it is when it gets injected into the</p> <p>3 body.</p> <p>4 Q. If we look at the "Results" section, it's</p> <p>5 on page 2. Do you see the second subsection?</p> <p>6 Page 2.</p> <p>7 A. Oh, page 2. I was looking at Figure 2.</p> <p>8 Sorry.</p> <p>9 Q. The second subsection under the heading</p> <p>10 "Results," reports "Full-length S DNA and S1</p> <p>11 protein elicit high titers of NAb in mice." Do</p> <p>12 you see that?</p> <p>13 A. I see that.</p> <p>14 Q. And do you see where it says "Mice" were</p> <p>15 "primed either" . . . "with S1 protein or twice</p> <p>16 with S DNA and then boosted once with S1 protein</p> <p>17 generated the highest neutralizing antibody (NAb)</p> <p>18 titers among all groups. The full-length S DNA</p> <p>19 regimen induced a significantly higher antibody</p> <p>20 response than the truncated S" -- and it has a</p> <p>21 little triangle -- "TM or S1 DNA regimens." Do</p> <p>22 you see that?</p>
<p>146</p> <p>1 MERS-CoV spike protein. Right?</p> <p>2 A. It describes, yeah, the DNA vaccine</p> <p>3 encoding the spike protein.</p> <p>4 Q. And I think your declaration discussed the</p> <p>5 central dogma of biology, right, the central dogma</p> <p>6 being the fact that DNA is transcribed into mRNA,</p> <p>7 which is then translated into a protein.</p> <p>8 A. That's correct. Yes.</p> <p>9 Q. So under that central dogma, the DNA</p> <p>10 vaccine encoding MERS-CoV spike protein was</p> <p>11 transcribed into mRNA encoding for the MERS-CoV</p> <p>12 spike protein. Correct?</p> <p>13 A. So when a DNA vaccine gets injected into</p> <p>14 the body, it will transcribe into mRNA and then</p> <p>15 become a protein. When an mRNA gets injected in</p> <p>16 the body, the mRNA gets transcribed into protein.</p> <p>17 But that doesn't make DNA and mRNA the</p> <p>18 same thing. They both end up in protein. So we</p> <p>19 wouldn't say that DNA and mRNA vaccines are</p> <p>20 protein vaccines any more that we would say that a</p> <p>21 DNA is an mRNA vaccine simply because it makes</p> <p>22 mRNA when it gets injected.</p>	<p>148</p> <p>1 A. All right. So we've introduced another</p> <p>2 immunogen here, which is the transmembrane region</p> <p>3 of that S protein.</p> <p>4 So mice are primed once either with</p> <p>5 protein or twice with DNA. So we've got</p> <p>6 S1 protein or twice with full-length S protein</p> <p>7 DNA. And then they are all boosted with</p> <p>8 S1 protein to generate neutralizing antibody.</p> <p>9 What I don't understand -- and I'd have to</p> <p>10 read it -- is where the truncated transmembrane</p> <p>11 one comes in because that's not what they -- it</p> <p>12 says mice are primed with S1 protein or twice with</p> <p>13 full-length S DNA and then boosted with protein.</p> <p>14 And now all of a sudden we're talking</p> <p>15 about the -- so I'd have to look at the results</p> <p>16 because what they're describing here isn't</p> <p>17 matching up with --</p> <p>18 Q. Do you see where it says the full-length S</p> <p>19 DNA regimen induced a significantly higher</p> <p>20 antibody response than the truncated regimen?</p> <p>21 MR. PRUSSIA: Object to the form. In the</p> <p>22 mice.</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

Conducted on August 2, 2024

<p style="text-align: right;">149</p> <p>1 A. So I'm going to look at the data, I guess, 2 on Figure 1b. So they were primed DNA, they've 3 got protein, they have a delta TM, which would be, 4 according to the figure, would be a truncated 5 version of the full-length S protein. 6 So if you -- they have three different 7 things that they're comparing where they immunized 8 three times with DNA, prime boost 1 and boost 2 or 9 two times with DNA and then boost with protein, 10 the protein is always S1. 11 And then they just do two times with 12 protein. And then they look at neutralizing 13 antibody responses after each immunization. 14 They see induction neutralizing antibody. 15 The highest neutralizing antibody is in the 16 heterologous prime boost where you prime twice 17 with DNA and boost with protein. That's a common 18 phenomenon there. But it's not even higher than 19 just twice with protein alone. 20 Q. Have you got your bearings? 21 A. I've got it. I think I've got it. I 22 think I'm just trying to connect here because the</p>	<p style="text-align: right;">151</p> <p>1 that -- 2 Q. I'd like you to answer my question rather 3 than just explain -- 4 A. What's your question again? 5 Q. Does this teach that a MERS S protein- 6 based vaccine induced a significantly higher 7 antibody response than the truncated S protein or 8 S protein subunit-based vaccines? 9 MR. PRUSSIA: Objection to the form of the 10 question. 11 A. So I don't know if it teaches it, but I do 12 know what the data shows. 13 Q. Okay. 14 A. And we're comparing -- again, could you 15 remind me which two you want me to compare? 16 Q. The full-length S protein versus truncated 17 or S protein subunit-based vaccines. 18 A. As a protein vaccine? As a DNA vaccine or 19 the heterologous prime boost? 20 Q. DNA vaccine. 21 A. As just the DNA vaccine. 22 So the panel shows that the S1 subunit,</p>
<p style="text-align: right;">150</p> <p>1 description of what the mice were immunized with, 2 it doesn't entirely match up with all of the 3 different immunogens or testing because there's -- 4 it looks like a spike protein with a transmembrane 5 portion has been deleted. So it's not full-length 6 spike protein. It's a shortened spike protein. 7 Q. Is it fair to say that a scientist would 8 want a vaccine to induce a higher antibody 9 response? 10 A. So the goal of this paper was certainly to 11 maximize the titer of neutralizing antibody. And 12 I believe that was the objective of the experiment 13 here is to determine what regimen but also what 14 immunogen is going to give you the highest 15 neutralizing antibody. 16 Q. And this article teaches that a 17 MERS S protein-based vaccine induced a 18 significantly higher antibody response than the 19 truncated S protein or S protein subunit based 20 vaccines. Correct? 21 MR. PRUSSIA: Object to the form. 22 A. So I can explain what this shows, is</p>	<p style="text-align: right;">152</p> <p>1 the full-length S protein three times with DNA 2 induced statistically higher neutralizing antibody 3 than the S delta TM and the S1 subunit. 4 So -- and the question is would we want -- 5 the purpose here was to induce the highest 6 neutralizing antibody possible. 7 And so the bigger question is would we 8 want to see higher neutralizing antibody. 9 And my answer to that is that maybe not 10 necessarily. And one of the reasons is because in 11 2015 there was already evidence that the 12 full-length S protein could be associated with 13 enhancement of infection. 14 I'm familiar with a paper that explored 15 the development of the delta transmembrane spike 16 protein as a strategy to avoid enhancement of 17 infection. 18 So getting more antibody is not 19 necessarily always better. You had to take into 20 context whether the higher antibody response now 21 increases the risk for that vaccine to enhance 22 disease.</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 39 of 130

Conducted on August 2, 2024

<p>153</p> <p>1 Q. Let's go back to the claims of the patent</p> <p>2 for a moment, and I'd like to take you to the</p> <p>3 claims of the '127 patent.</p> <p>4 All right. Claim 1 of the '127 patent</p> <p>5 reads, "A method comprising administering to a</p> <p>6 subject a messenger ribonucleic acid (mRNA)</p> <p>7 comprising an open reading frame encoding a</p> <p>8 betacoronavirus (BetaCoV) S protein or S protein</p> <p>9 subunit formulated in a lipid nanoparticle in an</p> <p>10 effective amount to induce in the subject an</p> <p>11 immune response to the BetaCoV S protein or</p> <p>12 S protein subunit, wherein the lipid nanoparticle</p> <p>13 comprises 20-60 mol % ionizable cationic lipid,</p> <p>14 5-25 mol % neutral lipid, 25-55 mol % cholesterol,</p> <p>15 and 0.5-15 mol % PEG-modified lipid." Do you see</p> <p>16 that?</p> <p>17 A. I see that.</p> <p>18 Q. And it is directed to a method rather than</p> <p>19 a composition. Correct?</p> <p>20 A. It starts with the two words "A method."</p> <p>21 Q. Do you have any understanding as to what</p> <p>22 levels of immune response is required by Claim 1?</p>	<p>155</p> <p>1 MR. PRUSSIA: Objection, asked and</p> <p>2 answered.</p> <p>3 Q. You can answer.</p> <p>4 A. It would be, say, an immune response.</p> <p>5 It's a general term.</p> <p>6 Q. Any immune response?</p> <p>7 A. Right. But there are additional</p> <p>8 clarifications to that, that what they are</p> <p>9 targeting is actually neutralizing antibody</p> <p>10 response.</p> <p>11 Q. What level of neutralizing antibody</p> <p>12 response is required?</p> <p>13 A. So are we talking about what the claim is</p> <p>14 saying or are you just asking me in general what</p> <p>15 level of neutralizing antibody response?</p> <p>16 Q. I'm asking you your understanding of the</p> <p>17 level of neutralizing antibody response required</p> <p>18 by the claims.</p> <p>19 A. Whether the claim requires a level of</p> <p>20 neutralizing antibody? Is that what you're asking</p> <p>21 me?</p> <p>22 Q. That's what I'm asking you.</p>
<p>154</p> <p>1 A. So which words are you referring to?</p> <p>2 Induce -- amount to induce in the subject an</p> <p>3 immune response, an effective amount to induce in</p> <p>4 a subject an immune response?</p> <p>5 Is that what you're referring to?</p> <p>6 Q. I'm referring to the immune response</p> <p>7 language that you've pointed out.</p> <p>8 And my question is, do you have any</p> <p>9 understanding as to what level of immune response</p> <p>10 is required by the claim?</p> <p>11 A. So that would have to be the protective</p> <p>12 level.</p> <p>13 Q. What in the language of the claim tells</p> <p>14 you that it has to be a protective level?</p> <p>15 A. So to induce an immune response. That's</p> <p>16 what you would want, is a protective level. Say</p> <p>17 just an immune response.</p> <p>18 Q. Does it say "protective level" or does it</p> <p>19 just say "an immune response"?</p> <p>20 A. It just says "an immune response."</p> <p>21 Q. So is it fair to say that Claim 1 covers</p> <p>22 any type or any level of immune response?</p>	<p>156</p> <p>1 A. The claim doesn't say a required</p> <p>2 neutralizing antibody at that point.</p> <p>3 Q. So it's directed only to any neutralizing</p> <p>4 antibody response. Is that fair?</p> <p>5 MR. PRUSSIA: Object to the form,</p> <p>6 mischaracterizes the testimony.</p> <p>7 A. No. Sorry. That's not what I'm saying.</p> <p>8 Q. What are you saying?</p> <p>9 A. So it would have to be specific to</p> <p>10 S protein, structural S protein or one of the</p> <p>11 subunits.</p> <p>12 Q. We talked about this before, so we can do</p> <p>13 this quickly if you don't know.</p> <p>14 Claim 1 is directed to a lipid</p> <p>15 nanoparticle comprising a number of different</p> <p>16 categories. Four, in fact: Ionizable cationic</p> <p>17 lipid, neutral lipid, cholesterol, and</p> <p>18 PEG-modified lipid. Right?</p> <p>19 A. That's what it says.</p> <p>20 Q. Do you have any idea as to how many</p> <p>21 ionizable cationic lipids there currently are?</p> <p>22 A. You're outside my domain. This is not my</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 40 of 130

Conducted on August 2, 2024

<p>157</p> <p>1 area, and I wasn't asked to opine on that.</p> <p>2 Q. Do you know about the number of neutral</p> <p>3 lipids that exist?</p> <p>4 A. Again, I do not -- was not asked to opine</p> <p>5 on that.</p> <p>6 Q. Fair enough.</p> <p>7 MS. MAYS-WILLIAMS: Why don't we take</p> <p>8 another break. Should we do lunch?</p> <p>9 MR. PRUSSIA: I think that makes sense.</p> <p>10 (Lunch recess, 12:19 p.m. to 1:15 p.m.)</p> <p>11</p> <p>12</p> <p>13</p> <p>14</p> <p>15</p> <p>16</p> <p>17</p> <p>18</p> <p>19</p> <p>20</p> <p>21</p> <p>22</p>	<p>159</p> <p>1 Will you understand that the declaration</p> <p>2 in the 1358 case again contains a largely</p> <p>3 identical analysis?</p> <p>4 A. Largely similar. Yeah.</p> <p>5 Q. Okay. Your declaration related to the</p> <p>6 '127 patent is 464 pages long. Is that right?</p> <p>7 465, minus the appendices.</p> <p>8 A. Yes.</p> <p>9 Q. And your declaration related to the '127</p> <p>10 patent is 1,146 paragraphs. Right?</p> <p>11 A. That's what it looks like. Yes.</p> <p>12 Q. And your declaration relating to the '600</p> <p>13 patent is 458 pages. Is that right?</p> <p>14 A. 458. Yes.</p> <p>15 Q. And 1,153 paragraphs. Right?</p> <p>16 A. That's right.</p> <p>17 Q. Who wrote the declaration for the '127</p> <p>18 patent, the one that's just 465 pages long?</p> <p>19 A. So I collaborated with the attorneys to</p> <p>20 write this declaration.</p> <p>21 Q. What was that collaboration process like?</p> <p>22 A. So I describe it very similar to a process</p>
<p>158</p> <p>1 AFTERNOON SESSION</p> <p>2 BY MS. MAYS-WILLIAMS:</p> <p>3 Q. Okay. So I'd like to just switch gears a</p> <p>4 little in view of the background that we've gone</p> <p>5 over prior to our lunch break.</p> <p>6 And I want to talk a little bit in more</p> <p>7 detail about the declarations that you've</p> <p>8 submitted in connection with these proceedings.</p> <p>9 Both exhibits I believe are marked 2199.</p> <p>10 Is that right?</p> <p>11 A. Right. They both have the number 2199.</p> <p>12 One says '127 and the other one refers to</p> <p>13 the '600.</p> <p>14 Q. You would agree that both declarations are</p> <p>15 substantively quite similar. Correct?</p> <p>16 A. They are very similar. Yes.</p> <p>17 Q. And why is that?</p> <p>18 A. Well, because the '127 is based off of the</p> <p>19 '600 as a priority date.</p> <p>20 Q. I'd like to predominantly refer to your</p> <p>21 declaration in the 1359 case, which relates to the</p> <p>22 '127 patent.</p>	<p>160</p> <p>1 that as a scientist I use when I collaborate to</p> <p>2 write a manuscript or a grant application where</p> <p>3 multiple people were involved in putting together</p> <p>4 the information that we're going to incorporate</p> <p>5 into the document, writing various parts of it,</p> <p>6 reviewing, revising multiple times different sorts</p> <p>7 of drafts, where ultimately if I'm the primary,</p> <p>8 principal investigator on a grant, like this</p> <p>9 declaration, or the primary author on a</p> <p>10 manuscript, I go through everything and make sure</p> <p>11 that it's consistent.</p> <p>12 Q. You likened this process to the process</p> <p>13 that you undertake when you're preparing a</p> <p>14 manuscript for submission to a scientific journal.</p> <p>15 Right?</p> <p>16 A. Or a grant application. Yeah. Probably</p> <p>17 closer to a grant application because there's much</p> <p>18 more structure, different sorts of sort of</p> <p>19 formatting that is required that is, you know,</p> <p>20 different from a manuscript.</p> <p>21 Q. In preparing these types of manuscripts or</p> <p>22 grant applications, as a principal investigator do</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 41 of 130

Conducted on August 2, 2024

<p>161</p> <p>1 you typically provide the first draft or does 2 someone else do that?</p> <p>3 A. So it depends on what kind of document it 4 is and who I'm collaborating with in terms of 5 cowriting that.</p> <p>6 So for example, if it's another 7 coinvestigator who runs their own lab who they did 8 maybe a portion of the work, or in a grant 9 application they're going to be -- they have the 10 expertise for a particular area.</p> <p>11 Like if we say, for example, in a 12 collaboration with more people more familiar with 13 legal stuff, then they would bring legal 14 information to the table, and I would bring 15 science information to the table. And the stuff 16 that we would contribute in terms of writing would 17 be within our respective domains.</p> <p>18 And then we would write everything 19 together and revise. I'm very picky about words, 20 so I end up going through everything pretty 21 tightly.</p> <p>22 Q. Who provided the first draft of the '127</p>	<p>163</p> <p>1 particular -- my words may look a little bit 2 different than what I originally put in.</p> <p>3 Q. Is it your testimony that you provided an 4 initial text, content, and the like but in the 5 final draft it's hard for you to discern what you 6 originally put in?</p> <p>7 A. It's -- I can discern in terms of the 8 content what I contributed. If you want me to say 9 what specific words did I write, in a given 10 sentence maybe three of the words I wrote, four of 11 the words somebody else wrote. That's the nature 12 of a collaboration when you're cowriting 13 something.</p> <p>14 Q. So is it your testimony that on average in 15 a seven-sentence --</p> <p>16 A. That's not my testimony. I know where 17 you're going with it. That's not what I'm saying. 18 I'm giving that as an example.</p> <p>19 Q. Are you able to provide testimony as to 20 the content that you provided for the '127 21 declaration?</p> <p>22 A. Am I able to provide testimony for the</p>
<p>162</p> <p>1 patent declaration?</p> <p>2 A. So the first complete draft was a 3 collaboration between both -- between me and the 4 lawyers.</p> <p>5 Q. And is that same for the '600 --</p> <p>6 A. Correct.</p> <p>7 Q. -- declaration?</p> <p>8 A. Correct. The entire first draft was a 9 collaboration.</p> <p>10 Q. Did you personally write any aspect of the 11 '127 or the '600?</p> <p>12 A. I personally wrote several aspects. Yes. 13 Quite a bit of content.</p> <p>14 Q. Which sections of the '127 declaration did 15 you personally write yourself?</p> <p>16 A. So let me clarify.</p> <p>17 When I say "personally write," that means 18 would have contributed the initial text, content, 19 and the like.</p> <p>20 By the time we get to the final draft, 21 it's very hard to discern once people edit, 22 revise, make sure, reformat, and the like, what</p>	<p>164</p> <p>1 content in here?</p> <p>2 Q. Let me ask a better question.</p> <p>3 What content did you provide for the '127 4 declaration?</p> <p>5 I'm sorry. Let's just slow down and try 6 not to talk over each other.</p> <p>7 I believe earlier you testified that you 8 would have contributed an initial text, content, 9 and the like. And I just want to understand what 10 content you provided with respect to the '127 11 patent declaration.</p> <p>12 A. Do you want specific components or 13 sections or what are you looking for when you say 14 "content"?</p> <p>15 Q. What sections did you contribute to for 16 the '127 patent?</p> <p>17 A. So I would have contributed in some manner 18 or another to every section.</p> <p>19 Q. And is the same true of the '600 patent 20 declaration?</p> <p>21 A. That's correct.</p> <p>22 Q. Did you personally write any portions of</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

Conducted on August 2, 2024

<p>165</p> <p>1 the '127 declaration?</p> <p>2 A. I personally wrote portions of both</p> <p>3 declarations.</p> <p>4 Q. Do you know which portions you personally</p> <p>5 wrote?</p> <p>6 A. So let me clarify.</p> <p>7 Again, what you mean by "personally</p> <p>8 write," do you mean that every word in a given</p> <p>9 paragraph would have been exactly only me writing</p> <p>10 it or are we talking about the final edited</p> <p>11 content, which would have resulted from a back-</p> <p>12 and-forth? You know how it goes, back and forth</p> <p>13 in terms of collaboration of editing drafts.</p> <p>14 Q. What portions of the '127 declaration did</p> <p>15 you sit at your computer and personally type up,</p> <p>16 if any?</p> <p>17 A. So let me put it in my own words.</p> <p>18 What portions did I contribute when we go</p> <p>19 through, we talk about my background, who I am.</p> <p>20 Those are things that I contributed.</p> <p>21 When we talk about basic science, the</p> <p>22 foundations, what is a DNA, what is an RNA</p>	<p>167</p> <p>1 A. Physically drafted, revised, or edited.</p> <p>2 Yes.</p> <p>3 Q. Is the same true for the '600 patent</p> <p>4 declaration?</p> <p>5 A. Yes. Or approved as written.</p> <p>6 Q. You said "Or approved as written." What</p> <p>7 do you mean by that?</p> <p>8 A. That means there would be sections in</p> <p>9 which I would have -- that somebody else would</p> <p>10 have initially written at their computer. I would</p> <p>11 have run through that. I would not have found any</p> <p>12 issues with the words or how they were structured</p> <p>13 or what they were saying and would not have -- I'd</p> <p>14 say there were maybe two sentences in a row where</p> <p>15 I didn't have any redline, for example.</p> <p>16 Q. So there are some sections that you</p> <p>17 contributed the initial content for. Correct?</p> <p>18 A. Yes, there are sections that I contributed</p> <p>19 the initial content for.</p> <p>20 Q. And there's some sections that you</p> <p>21 approved as written. Is that fair?</p> <p>22 A. That I would have edited and gone through</p>
<p>166</p> <p>1 vaccine, I contributed to that section.</p> <p>2 These are just examples. And you start to</p> <p>3 kind of walk through -- we can go through the</p> <p>4 entire thing and we can walk through it if you'd</p> <p>5 like.</p> <p>6 Q. Why don't we go to the table of contents,</p> <p>7 and you let me know which portions of the sections</p> <p>8 that are laid out in the table of contents you</p> <p>9 drafted content for.</p> <p>10 A. So I contributed to every single portion</p> <p>11 of this.</p> <p>12 Q. You mentioned physically sitting at your</p> <p>13 keyboard and typing up information that was</p> <p>14 relevant to your background and basic --</p> <p>15 A. Physically sitting at my computer and</p> <p>16 going through this entire draft and every single</p> <p>17 section physically, actually writing words to</p> <p>18 incorporate in all of these.</p> <p>19 Q. So it's your testimony that you sat at</p> <p>20 your computer and physically drafted content for</p> <p>21 every section that's laid out in the table of</p> <p>22 contents here?</p>	<p>168</p> <p>1 and reviewed.</p> <p>2 Q. Can you tell me which sections you would</p> <p>3 have approved as written for your '127 patent</p> <p>4 declaration?</p> <p>5 A. I don't know that I can remember that</p> <p>6 precisely.</p> <p>7 Q. Would you have just approved as written</p> <p>8 the section that relates to the legal standards?</p> <p>9 A. Could you point me to which section</p> <p>10 that --</p> <p>11 Q. In your table of contents, Section 3, it</p> <p>12 says "Legal Standards."</p> <p>13 A. So those are things I would have read</p> <p>14 through. And I actually did edit some things.</p> <p>15 Q. And the person of ordinary skill in the</p> <p>16 art, did you approve as written that section?</p> <p>17 A. I reviewed it, and I don't remember if I</p> <p>18 made edits to it at all.</p> <p>19 Q. The technology background, what about that</p> <p>20 section? Is that something you approved as</p> <p>21 written or contributed content for?</p> <p>22 A. So as I mentioned, the entire document in</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 43 of 130

Conducted on August 2, 2024

<p style="text-align: right;">169</p> <p>1 this section as well would have been sections that</p> <p>2 I would have contributed, sections I would have</p> <p>3 edited, some sections I would have revised,</p> <p>4 sections I would have approved.</p> <p>5 It's probably not even sections so much as</p> <p>6 just words, fragments, and phrases, sentences here</p> <p>7 and there. That's kind of the nature of</p> <p>8 collaborating on a document.</p> <p>9 Q. Are there any sections that you can</p> <p>10 recognize now, sitting here today, as sections</p> <p>11 that you did not contribute to in terms of the</p> <p>12 original first draft content?</p> <p>13 A. Should I find something? Is that what you</p> <p>14 want me to do? Just point out a paragraph?</p> <p>15 Q. Why don't we stick with the table of</p> <p>16 contents, talk about sections.</p> <p>17 A. That would be harder for me to do because</p> <p>18 as we go through entire sections, I may have</p> <p>19 edited words and things like that. So you're</p> <p>20 asking is there sections that I just would have</p> <p>21 read and then just -- that, I don't know without</p> <p>22 really going through the entire document.</p>	<p style="text-align: right;">171</p> <p>1 declaration. That's the summary of your opinions.</p> <p>2 Correct?</p> <p>3 A. Yes.</p> <p>4 Q. What portion of the summary of opinions</p> <p>5 can you fully claim as your own?</p> <p>6 MR. PRUSSIA: Object to the form of the</p> <p>7 question.</p> <p>8 A. I take ownership over the entire summary,</p> <p>9 since I reviewed it all. I most certainly wrote</p> <p>10 portions of it. I most certainly made edits and</p> <p>11 revised it so that at the end of the day this was</p> <p>12 my voice speaking.</p> <p>13 Q. But the first draft of the summary of</p> <p>14 opinions was provided to you to sign off on. Is</p> <p>15 that --</p> <p>16 A. I'm not saying that. No.</p> <p>17 MR. PRUSSIA: Objection, mischaracterizes.</p> <p>18 Q. You said you take ownership over the</p> <p>19 entire summary because you reviewed it all.</p> <p>20 A. Correct.</p> <p>21 Q. Which portions of the summary of opinions</p> <p>22 did you provide input on the first draft for?</p>
<p style="text-align: right;">170</p> <p>1 Q. So you don't know which sections you</p> <p>2 contributed content for and which sections you</p> <p>3 just reviewed and approved. Is that fair?</p> <p>4 MR. PRUSSIA: Objection, mischaracterizes.</p> <p>5 A. Yes, you did mischaracterize what I said.</p> <p>6 If I went through the entire document and</p> <p>7 we walked through it page by page, I could</p> <p>8 probably walk through and identify parts that I</p> <p>9 may not have had to do -- even then, I would</p> <p>10 probably have to go back to my computer and look</p> <p>11 at earlier drafts to see if I actually made any</p> <p>12 edits or not.</p> <p>13 It's not a process that is quantitative in</p> <p>14 that way. It's a very organic process that</p> <p>15 undergoes multiple revisions and changes. So by</p> <p>16 the end of the day, even given manuscripts, the</p> <p>17 one you showed me before -- I don't know. I</p> <p>18 couldn't point to any specific words that I can</p> <p>19 fully claim are only my own and hadn't been edited</p> <p>20 by one of my collaborators and revised a little</p> <p>21 bit.</p> <p>22 Q. Can you go with me to page 104 of your</p>	<p style="text-align: right;">172</p> <p>1 MR. PRUSSIA: Objection, mischaracterizes.</p> <p>2 She said she most certainly wrote portions of it.</p> <p>3 She most certainly made edits and revised it so</p> <p>4 that "at the end of the day this was my voice</p> <p>5 speaking."</p> <p>6 So you can ask her a question that's</p> <p>7 consistent with her testimony.</p> <p>8 MS. MAYS-WILLIAMS: I'll ask the</p> <p>9 questions. You can make your objections.</p> <p>10 MR. PRUSSIA: Objection, mischaracterizes.</p> <p>11 Q. Which portions of the summary of opinions</p> <p>12 did you provide the first draft of, if any?</p> <p>13 A. As I mentioned, in writing a document like</p> <p>14 this, writing a grant application, and writing a</p> <p>15 manuscript, at the end of the day it's difficult</p> <p>16 without comparing side by side with the original</p> <p>17 draft for me to point to a specific thing.</p> <p>18 Honestly, I mean, I could take guesses.</p> <p>19 But I'm under oath, I guess, so I don't want to</p> <p>20 make a guess here.</p> <p>21 Q. Is it true that in the summary of opinions</p> <p>22 you can't point to a specific thing that you</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 44 of 130

Conducted on August 2, 2024

<p>173</p> <p>1 provided language for the first draft for?</p> <p>2 MR. PRUSSIA: Object to the form, asked</p> <p>3 and answered.</p> <p>4 A. That's not what I said.</p> <p>5 Q. I asked you which portions of the summary</p> <p>6 of opinions did you provide the first draft of.</p> <p>7 And your response was:</p> <p>8 "ANSWER: As I mentioned, in writing a</p> <p>9 document like this, grant application, or a</p> <p>10 manuscript, it's difficult without comparing side</p> <p>11 by side the original draft to point to any</p> <p>12 specific thing. I can take a guess."</p> <p>13 Do you remember --</p> <p>14 A. Yeah. So I could tell you precisely if I</p> <p>15 had the original drafts side by side with me.</p> <p>16 Q. So you just don't know?</p> <p>17 A. Today, I don't know. Not without</p> <p>18 additional information. I would need additional</p> <p>19 information to answer that question for you.</p> <p>20 Q. How many hours did you spend preparing</p> <p>21 your '127 declaration?</p> <p>22 A. I don't know precisely how many hours.</p>	<p>175</p> <p>1 Q. Okay. So around 30 hours for preparing</p> <p>2 the declaration. Let's just make sure we're not</p> <p>3 talking over each other.</p> <p>4 A. I want to make sure we're on the same</p> <p>5 page.</p> <p>6 Go ahead.</p> <p>7 Q. Around 30 hours for drafting the</p> <p>8 declarations, the '127 patent declaration and the</p> <p>9 '600 patent declaration. Did I get that right?</p> <p>10 A. That's a guess. Yeah.</p> <p>11 Q. Okay. What else did you do in terms of</p> <p>12 work for the '127 and the '600 patent</p> <p>13 declarations?</p> <p>14 A. So reading through the material, obviously</p> <p>15 reading the patents, reading a lot of stuff,</p> <p>16 everything that's referenced in there, and</p> <p>17 reviewing the literature.</p> <p>18 Q. And the materials and the literature that</p> <p>19 you mentioned reading and reviewing, those were</p> <p>20 all provided by the patent attorneys. Correct?</p> <p>21 A. Some of the material I found. Some of the</p> <p>22 material they found. There were also declarations</p>
<p>174</p> <p>1 Q. Approximately?</p> <p>2 A. I can't -- 30. I don't know. 30.</p> <p>3 Q. And about how many hours did you spend</p> <p>4 preparing your '600 patent declaration?</p> <p>5 A. The two were prepared in parallel.</p> <p>6 Q. Got it. So you prepared or reviewed and</p> <p>7 signed off on the 458-page '600 declaration and</p> <p>8 465-page '127 declaration all in about 30 hours?</p> <p>9 A. That's a guess.</p> <p>10 Q. Okay. When did you begin working on your</p> <p>11 declaration in this proceeding?</p> <p>12 A. I don't recall the date.</p> <p>13 Q. Do you recall approximately when you began</p> <p>14 working on the drafts of these documents?</p> <p>15 A. Actually, so we're talking about actually</p> <p>16 writing it?</p> <p>17 Q. Correct.</p> <p>18 A. Let me clarify, the 30 hours is when I was</p> <p>19 referring to the actual writing, not all the</p> <p>20 taking in resources and stuff like that in</p> <p>21 preparation for writing. There was a lot more</p> <p>22 time added to that.</p>	<p>176</p> <p>1 from, for example, Griffin. I read through that.</p> <p>2 Other material.</p> <p>3 Q. The list of materials considered is</p> <p>4 provided in Appendix B at the end of both</p> <p>5 declarations. Take a look at that for a moment.</p> <p>6 A. Are we on the same page?</p> <p>7 Q. At the very end, Appendix B.</p> <p>8 So for Appendix B of the '127 declaration,</p> <p>9 which materials did you provide to counsel, if</p> <p>10 any?</p> <p>11 A. I don't think I can remember them all. I</p> <p>12 can give you some examples. And then parts of it</p> <p>13 I don't remember, kind of all came up with it at</p> <p>14 the same time.</p> <p>15 Q. Which, if any, references listed in this</p> <p>16 materials considered list did you provide to</p> <p>17 counsel?</p> <p>18 A. Let's see. There is some references here</p> <p>19 about disease enhancement. There are references,</p> <p>20 reviews on RNA vaccine. There is --</p> <p>21 Q. Why don't we slow down for a minute. Why</p> <p>22 don't you identify by --</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 45 of 130

Conducted on August 2, 2024

<p>177</p> <p>1 MR. PRUSSIA: Hold on. She's still</p> <p>2 answering your question.</p> <p>3 Q. -- exhibit number --</p> <p>4 MR. PRUSSIA: Are you withdrawing your</p> <p>5 question?</p> <p>6 MS. MAYS-WILLIAMS: No, I'm not.</p> <p>7 MR. PRUSSIA: Then let her finish her</p> <p>8 answer, please.</p> <p>9 Q. Go ahead.</p> <p>10 A. So another review -- there's a review by</p> <p>11 Norbert Pardi. There is the reference for the</p> <p>12 Human Genome Research Institute.</p> <p>13 There's a lot of these that are just in --</p> <p>14 let me just clarify that a lot of these references</p> <p>15 are just in my general folder of references. I</p> <p>16 work in this domain, and I use these over and over</p> <p>17 again for a lot of my own documents.</p> <p>18 And so it's difficult for me to remember</p> <p>19 did I provide it specifically for this or am I</p> <p>20 recognizing that simply because it's in my</p> <p>21 portfolio, which I did share a lot from my</p> <p>22 portfolio of references with the attorneys here.</p>	<p>179</p> <p>1 to write this declaration.</p> <p>2 Q. How long did you spend putting together</p> <p>3 the resources needed to write the declaration?</p> <p>4 A. I don't remember. I started thinking</p> <p>5 about, you know -- I started putting it together</p> <p>6 in terms of the resources for my own work has been</p> <p>7 decades of putting together that portfolio, as it</p> <p>8 is, my go-to list whenever I start writing</p> <p>9 something related to my field.</p> <p>10 So how long specifically for this is -- I</p> <p>11 don't remember.</p> <p>12 Q. Do you know about how many hours you spent</p> <p>13 with counsel discussing the material that would go</p> <p>14 into the declarations?</p> <p>15 A. I don't really recall.</p> <p>16 Q. Do you know generally about how many</p> <p>17 meetings you had?</p> <p>18 A. No. There were several, though.</p> <p>19 Q. More than three?</p> <p>20 A. More than three.</p> <p>21 Q. More than five?</p> <p>22 A. More than five.</p>
<p>178</p> <p>1 Q. Other than the party reference and the</p> <p>2 Human Genome Research Institute reference, are you</p> <p>3 able to identify any others with certainty that</p> <p>4 you provided to counsel here?</p> <p>5 MR. PRUSSIA: Object to the form,</p> <p>6 mischaracterizes.</p> <p>7 A. So as I mentioned, there could be -- I</p> <p>8 have a portfolio that has many of these, if not</p> <p>9 most of these references.</p> <p>10 Many of these are -- for example,</p> <p>11 therapeutic vaccine in chronically HIV infected</p> <p>12 patients is my roster. Immunogenicity mRNA rabies</p> <p>13 vaccines in healthy adults.</p> <p>14 I have a portfolio of those that I keep</p> <p>15 because I use them over and over for my own</p> <p>16 documents.</p> <p>17 And I can't remember, because I did share</p> <p>18 a lot of those documents with the attorneys,</p> <p>19 whether or not they originally brought them to the</p> <p>20 table or did they pull them out of my -- did I</p> <p>21 share with them from my portfolio in the process</p> <p>22 of putting together the resources that we needed</p>	<p>180</p> <p>1 Q. More than seven?</p> <p>2 A. I think so. I don't know. If I pulled</p> <p>3 out my calendar, maybe I could find that</p> <p>4 information for you. But without really -- I</p> <p>5 don't want to -- I don't know.</p> <p>6 Q. Less than ten?</p> <p>7 A. My guess is more than ten, to be honest</p> <p>8 with you. But beyond that, I really can't</p> <p>9 pinpoint exactly how much time.</p> <p>10 Q. And for those ten or so meetings that you</p> <p>11 had with counsel, about how long were those</p> <p>12 meetings?</p> <p>13 A. They ranged. It just really depended on</p> <p>14 what we needed to talk about.</p> <p>15 Q. What was the range?</p> <p>16 A. It would be anywhere from 15 minutes to</p> <p>17 usually two hours was the most time I think at one</p> <p>18 time.</p> <p>19 Q. And that's, of course, spread across the</p> <p>20 '600 patent and the '127 patent?</p> <p>21 A. Yeah. Many of the references are the same</p> <p>22 between the two.</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 46 of 130

Conducted on August 2, 2024

<p>181</p> <p>1 Q. Section 3 of your report, which is the</p> <p>2 legal standards section. I'm on the '127 patent</p> <p>3 declaration now, page 6.</p> <p>4 Section 3 of your report discusses the</p> <p>5 legal standards that you applied in your</p> <p>6 declaration. Right?</p> <p>7 A. Uh-hmm.</p> <p>8 Q. And Section 3C discusses the anticipation</p> <p>9 legal standards that you applied. Is that</p> <p>10 correct?</p> <p>11 A. That's what it says. Yes.</p> <p>12 Q. So if we look at the anticipation section,</p> <p>13 your declaration reads that, "A patent claim is</p> <p>14 invalid for anticipation only if each and every</p> <p>15 limitation in the claim is disclosed either</p> <p>16 expressly or inherently in a single prior art</p> <p>17 reference." Correct?</p> <p>18 A. That's what it says.</p> <p>19 Q. And that's a legal standard that you</p> <p>20 applied for anticipation. Right?</p> <p>21 A. That's right.</p> <p>22 MR. PRUSSIA: Object to the form.</p>	<p>183</p> <p>1 A. Could you point to my declaration where I</p> <p>2 offered that opinion?</p> <p>3 Q. I can't point you to that.</p> <p>4 A. Whatever is in my declaration is what I</p> <p>5 have offered the opinion on.</p> <p>6 Q. Okay. Page 10, you provide the legal</p> <p>7 standard that counsel gave you with respect to a</p> <p>8 person of ordinary skill in the art. Is that</p> <p>9 correct?</p> <p>10 A. Yes.</p> <p>11 Q. And you're aware that the board adopted a</p> <p>12 definition of POSA in its institution decision.</p> <p>13 Right?</p> <p>14 A. Yes.</p> <p>15 Q. Have you read the board's institution</p> <p>16 decision?</p> <p>17 A. Section 38, yes.</p> <p>18 Q. Have you read the board's institution</p> <p>19 decision?</p> <p>20 A. It's included in my declaration. Yes.</p> <p>21 Q. Is that the portion -- the only portion of</p> <p>22 the institution decision that you've read?</p>
<p>182</p> <p>1 Q. And at Paragraph 24, your declaration</p> <p>2 states that "I understand an anticipating</p> <p>3 reference must be enabling." Is that correct?</p> <p>4 A. That's what it says.</p> <p>5 Q. If I use the term "Schrum" to refer to a</p> <p>6 reference, do you have an understanding to what</p> <p>7 reference I'm referring to?</p> <p>8 A. I believe you're referring to a patent.</p> <p>9 Q. U.S. 2013/026640, which we refer to as</p> <p>10 Schrum in this proceeding, has been deemed an</p> <p>11 anticipating reference by BioNTech and Pfizer.</p> <p>12 You understand that. Correct?</p> <p>13 A. Yes.</p> <p>14 Q. Have you offered an opinion that Schrum's</p> <p>15 disclosure is not enabling?</p> <p>16 A. Have I offered the opinion that Schrum's</p> <p>17 disclosure is not enabling?</p> <p>18 I've offered the opinion that Schrum's</p> <p>19 disclosure is about therapeutics.</p> <p>20 Q. My question is a little bit different.</p> <p>21 You have not offered the opinion that</p> <p>22 Schrum's disclosure is not enabling, have you?</p>	<p>184</p> <p>1 A. I've read other portions as well.</p> <p>2 Q. In Paragraph 38, you quote the board's</p> <p>3 definition of POSA. Is that right?</p> <p>4 A. That's quoted there. Yes.</p> <p>5 Q. And do you consider the board's definition</p> <p>6 to be accurate?</p> <p>7 A. Accurate in terms of?</p> <p>8 Q. Do you agree with the definition of a POSA</p> <p>9 that's provided here?</p> <p>10 A. Yes, I agree that this is a definition of</p> <p>11 a POSA. This is for -- that is a definition of a</p> <p>12 POSA. Yes.</p> <p>13 Q. And there's nothing about it that you</p> <p>14 disagree with?</p> <p>15 A. A team of researchers that cover those</p> <p>16 areas of research. Yes. I agree.</p> <p>17 Q. In Paragraph 39, you state that you</p> <p>18 qualify as a POSA as a member of the hypothetical</p> <p>19 research team, as described in Part 1 and Part 3</p> <p>20 of the POSA definition adopted by the board during</p> <p>21 its institution decision, and that you also have</p> <p>22 experience with Part 2 as described in that POSA</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 47 of 130

Conducted on August 2, 2024

<p>185</p> <p>1 definition. Correct?</p> <p>2 A. I do have -- I meet all those</p> <p>3 qualifications. Yes.</p> <p>4 Q. Is it your testimony that you meet the</p> <p>5 qualification as described in Part 2?</p> <p>6 A. Yes.</p> <p>7 Q. Not just that you have experience with</p> <p>8 Part 2.</p> <p>9 I just want to make sure I understand.</p> <p>10 A. The way I read one or more individuals</p> <p>11 with an advanced degree -- that means they could</p> <p>12 have an M.D. or Ph.D. and experience in drug</p> <p>13 delivery.</p> <p>14 So yes, I qualify. I have an advanced</p> <p>15 degree and I have experience in drug delivery of</p> <p>16 nucleic acid vaccines.</p> <p>17 Q. You don't dispute that Dr. Griffin meets</p> <p>18 the board's POSA definition, do you?</p> <p>19 A. I do not believe he meets the definition,</p> <p>20 as he doesn't have experience in the field of</p> <p>21 nucleic acid vaccines.</p> <p>22 Q. Is there a portion of the POSA definition</p>	<p>187</p> <p>1 A. It depends on the pathogen that you're</p> <p>2 talking about. But protein vaccines can be outer</p> <p>3 surface or they can be internal core proteins.</p> <p>4 Q. Why would the outer surface be a potential</p> <p>5 vaccine antigen?</p> <p>6 A. So the outer surfaces generally includes</p> <p>7 proteins that if targeted by a vaccine would be</p> <p>8 most likely a mechanism for neutralizing antibody,</p> <p>9 immediate protection.</p> <p>10 Q. There is a portion of your declaration</p> <p>11 that talks about traditional vaccines and</p> <p>12 nontraditional vaccines. Right?</p> <p>13 A. Right.</p> <p>14 Q. What type of vaccine is an mRNA vaccine?</p> <p>15 A. That would be nontraditional.</p> <p>16 Q. So unlike DNA, viral vector, and saRNA</p> <p>17 vaccines, mRNA vaccines don't require multiple</p> <p>18 steps between cellular entry and production of the</p> <p>19 antigen of interest. Is that correct?</p> <p>20 A. Would you state that again? It seems to</p> <p>21 be missing some information there.</p> <p>22 Q. Unlike DNA, viral vector, and saRNA</p>
<p>186</p> <p>1 that requires experience with nucleic acid</p> <p>2 vaccines?</p> <p>3 A. Experience in vaccines, yes. There is</p> <p>4 that requirement. And then experience in nucleic</p> <p>5 acid therapeutics and vaccines.</p> <p>6 Q. Let's go to Paragraph 50 of your</p> <p>7 declaration for a moment.</p> <p>8 A. Paragraph 50?</p> <p>9 Q. Yes.</p> <p>10 At Paragraph 50 you wrote, "During the mid</p> <p>11 20th century came the development of protein</p> <p>12 vaccines which include only a protein of the</p> <p>13 pathogen instead of the entire pathogen. For</p> <p>14 example, a protein found on the outer surface of a</p> <p>15 virus as shown above in Figure 2 in my report."</p> <p>16 Do you see that?</p> <p>17 A. Yes.</p> <p>18 Q. Why did you specify that the protein could</p> <p>19 be found on the outer surface?</p> <p>20 A. That's an example.</p> <p>21 Q. Would a protein found on the outer surface</p> <p>22 of a virus be a typical vaccine antigen?</p>	<p>188</p> <p>1 vaccines, mRNA vaccines don't require multiple</p> <p>2 steps between cellular entry and production of the</p> <p>3 antigen of interest. Is that correct?</p> <p>4 A. So once the messenger RNA get inside the</p> <p>5 cell, it can be transcribed -- translated directly</p> <p>6 into protein.</p> <p>7 Q. And so therefore, mRNA vaccines utilize a</p> <p>8 more efficient cellular pathway to achieve</p> <p>9 expression of the encoded antigen. Right?</p> <p>10 A. That's not what I said. But it's directly</p> <p>11 translated. Yes.</p> <p>12 Q. Is that a fair statement, what I said,</p> <p>13 that mRNA vaccines utilize a more efficient</p> <p>14 cellular pathway to achieve expression of the</p> <p>15 encoded antigen?</p> <p>16 A. It depends on how you define "efficient."</p> <p>17 For example, self-amplifying RNA amplifies the</p> <p>18 transcripts. So it depends on how you define</p> <p>19 "efficient."</p> <p>20 Q. Fair to say that mRNA vaccines offer</p> <p>21 certain advantages as compared to other</p> <p>22 nontraditional vaccines. Correct?</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 48 of 130

Conducted on August 2, 2024

<p>189</p> <p>1 A. So there are advantages to mRNA vaccines, 2 especially depending upon the pathogen or the 3 indication that you're using it for. 4 Q. And you'd agree that mRNA is a 5 nonintegrating platform and therefore it doesn't 6 carry the risk of insertional immunogenesis. 7 Correct? 8 MR. PRUSSIA: Object to the form. 9 A. And what are you comparing that to? 10 Q. DNA, for example. 11 A. mRNA versus DNA vaccines. The DNA 12 vaccines do have a theoretical risk simply because 13 they have to go in through the nuclease whereas 14 mRNA vaccines never enter the nuclease. 15 However, the decades and decades of 16 research of DNA vaccines have shown not a single 17 incidence where a DNA vaccine will result in 18 integration. So it's just still to this day a 19 theoretical risk. And the field at large has -- 20 agrees that DNA vaccines really don't pose that 21 particular risk any more than mRNA vaccines do. 22 Q. mRNA is degraded by normal cellular</p>	<p>191</p> <p>1 Correct? 2 A. Yes. That particular manuscript was not 3 about safety as much as immunogenicity. 4 Q. Would you agree that modified nucleosides 5 can make mRNA more stable and highly translatable? 6 MR. PRUSSIA: Object to the form. 7 A. So modified what? Modified what? Can you 8 be more specific? 9 Q. It's been known since 2008 that the 10 inclusion of pseudouridine into mRNA can result in 11 a more stable and more highly translatable mRNA. 12 Correct? 13 A. The study by Karikó and Weissman showed 14 that when they incorporated pseudouridines into 15 mRNA, that increased the production of protein 16 while decreasing the immunogenicity. 17 Q. And you'd agree that an efficient in vivo 18 delivery can be achieved by formulating mRNA into 19 carrier molecules allowing rapid uptake and 20 expression in cytoplasm. Right? 21 MR. PRUSSIA: Object to the form. 22 Q. I think you were going to answer until you</p>
<p>190</p> <p>1 processes. Right? 2 A. So once the mRNA is translated, the RNA 3 will be degraded. 4 Q. And the inherent immunogenicity of mRNA 5 can be modulated using modified nucleosides to 6 increase the safety profile of an mRNA vaccine. 7 Is that right? 8 A. So -- 9 MR. PRUSSIA: Objection, just vague as to 10 date. 11 A. Could you restate that? 12 Q. The inherent immunogenicity of mRNA can be 13 modulated using modified nucleosides to increase 14 the safety profile of an mRNA vaccine. Is that 15 right? 16 MR. PRUSSIA: Same objections as to vague. 17 A. So can we revisit what are the safety 18 concerns of an mRNA vaccine. To get to that 19 answer to that question, I'd have to talk about 20 that. 21 Q. We looked at the Dr. Karikó and Weissman 22 publication earlier this morning to this point.</p>	<p>192</p> <p>1 heard the objection. So go ahead. 2 A. I was going to explain what I see rather 3 than just agree directly with you. 4 So it's that RNA, mRNA, does require a 5 vehicle to get efficient delivery. It can be 6 delivered naked. It can be injected and you can 7 still get an immune response. 8 But to get -- if you -- to get levels of 9 protein that you need to -- for gene therapy or 10 for an immune response, it's well known now that 11 you need a delivery vehicle. 12 It could be liposomes, it could be 13 protamine, lipid nanoparticles. There's gene gun. 14 There's all kinds of methods to more efficiently 15 deliver mRNA than as a naked delivery. 16 Q. Efficient delivery of mRNA allows for 17 rapid uptake and expression in cytoplasm. Right? 18 A. In cyto what? 19 Q. In cytoplasm. 20 A. Inside the cytoplasm. So then repeat that 21 again? 22 Q. Efficient delivery of mRNA allows for</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 49 of 130

Conducted on August 2, 2024

<p>193</p> <p>1 rapid uptake and expression in cytoplasm.</p> <p>2 Correct?</p> <p>3 A. When we talk about efficient delivery,</p> <p>4 we're talk about getting RNA -- a dose of RNA, the</p> <p>5 majority of that dose to actually be what's given</p> <p>6 to the cytoplasm. And then once inside the</p> <p>7 cytoplasm, it can be expressed.</p> <p>8 Q. An efficient delivery of mRNA into the</p> <p>9 cytoplasm allowing for expression was known by</p> <p>10 October 2015. Right?</p> <p>11 A. Are you reading somewhere in my</p> <p>12 declaration that I can --</p> <p>13 Q. No. I'm actually just reading it the --</p> <p>14 A. I'm just trying to follow where -- so</p> <p>15 efficient delivery of RNA into the cytoplasm --</p> <p>16 what was it?</p> <p>17 Q. Allowing for expression was known by</p> <p>18 October 2015. Right?</p> <p>19 A. So by 2015, there were various -- a range</p> <p>20 of different techniques and technologies that were</p> <p>21 out there that had been published in combination</p> <p>22 with mRNA to increase the efficiency of its</p>	<p>195</p> <p>1 RNA.</p> <p>2 But let me even characterize that further.</p> <p>3 Even within the whole class of nucleic acid</p> <p>4 vaccines, there was huge skepticism surrounding</p> <p>5 the entire body of them.</p> <p>6 Among those, if we think of DNA,</p> <p>7 self-amplifying RNA, mRNA, mRNA was the least</p> <p>8 promising or I believe the one that was held in</p> <p>9 greatest skepticism at that time.</p> <p>10 Simply, there was just very few studies to</p> <p>11 demonstrate the mRNA vaccines -- issues with both</p> <p>12 the efficiency of delivery, the expression.</p> <p>13 A lot of concerns about mRNA vaccines in</p> <p>14 terms of their stability existed. There were a</p> <p>15 lot more publications on DNA vaccines, on</p> <p>16 self-amplifying RNA vaccines.</p> <p>17 And even beyond that, there was a lot more</p> <p>18 work in the greater vaccinology field, other</p> <p>19 traditional means of vaccination, including live</p> <p>20 viral vector vaccines, recombinant protein</p> <p>21 vaccines, inactivated vaccines, and so on.</p> <p>22 I would say in 2015 probably the</p>
<p>194</p> <p>1 delivery and expression in vivo.</p> <p>2 That includes multiple different</p> <p>3 liposomes, chemical formulations, nanoparticles,</p> <p>4 physical delivery. Quite a variety of different</p> <p>5 delivery methods that were being tested.</p> <p>6 Q. In your declaration, you cited a few</p> <p>7 articles for the proposition that the field was</p> <p>8 still skeptical of mRNA vaccines. Right?</p> <p>9 A. Could you point that to me in my</p> <p>10 declaration, where that would be?</p> <p>11 Q. Turn to Paragraph 72.</p> <p>12 A. Okay. Right.</p> <p>13 Q. You mentioned skepticism of mRNA vaccines</p> <p>14 in 2015. Right?</p> <p>15 A. Yes.</p> <p>16 Q. What was the field skeptical of?</p> <p>17 A. So there was a large body of research that</p> <p>18 had been done on nucleic acid vaccines in general</p> <p>19 prior to 2015. There were certainly efforts going</p> <p>20 on with mRNA vaccines, but by far the majority of</p> <p>21 the field was focused -- when we talk about</p> <p>22 nucleic acid vaccines on DNA and self-amplifying</p>	<p>196</p> <p>1 predominant vaccine interest that was cutting-edge</p> <p>2 and experimental would have been a live viral</p> <p>3 vector priming followed by a recombinant</p> <p>4 booster -- protein booster immunization.</p> <p>5 And there were some obviously people still</p> <p>6 working on nucleic acid vaccines. But overall,</p> <p>7 there was a lot of skepticism around them because</p> <p>8 there had to date been no effective nucleic acid</p> <p>9 vaccine in a clinical trial.</p> <p>10 Q. By 2015, it was known that mRNA vaccines</p> <p>11 could induce some immune response. Right?</p> <p>12 A. There were some publications</p> <p>13 demonstrating -- and in fact, even before that</p> <p>14 there would have been papers, even naked mRNA</p> <p>15 demonstrating some immune response, but not</p> <p>16 necessarily very compelling in terms of the level</p> <p>17 of the response.</p> <p>18 Q. And by 2015, it was known that mRNA</p> <p>19 vaccines could induce the production of at least</p> <p>20 some neutralizing antibodies. Right?</p> <p>21 A. So there were some studies demonstrating</p> <p>22 mRNA vaccines, for example, formulated with</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 50 of 130

Conducted on August 2, 2024

<p style="text-align: right;">197</p> <p>1 protamine and injected into mice, for example, 2 like, one of the most common sort of animal models 3 to use to demonstrate initial proof of concept 4 with a vaccine is influenza in mice. It's very 5 easy to induce immune responses against those 6 immunogens, and it's very easy to protect mice 7 from it. So it's the first kind of step that 8 people would take if they want to try to test new 9 platforms. 10 So there was some experiments with mRNA 11 formulated, for example, with protamine that 12 looked -- that had induced neutralizing antibodies 13 in mice and even protection from sort of a low-bar 14 influenza challenge. 15 Q. And by 2015, it was known that mRNA could 16 be encapsulated by things like lipid 17 nanoparticles. Right? 18 A. So the lipid nanoparticle field by 2015 19 was very much focused on delivery of different 20 RNAs and even DNAs for gene therapy. 21 Q. Let's turn to Paragraph 72 in the 22 declaration that's right before you again.</p>	<p style="text-align: right;">199</p> <p>1 A. That's what is written. Yes. 2 Q. And the Pardi publication was published 3 from -- in January of 2018? 4 A. That's right. 5 Q. And the second column on the first page of 6 Pardi -- actually, before we do that, the sentence 7 that you cited is at the bottom of the first 8 column on page 261. Right? 9 So I'm in the first column now, the bottom 10 of -- you're in the second column. The first 11 column. 12 A. Oh, the first column. I'm sorry. Okay. 13 Q. The sentence starts with, "However, these 14 early promising results did not lead to 15 substantial investment." 16 Do you see that? It's about seven lines 17 from the bottom. 18 A. Okay. "However." Right. 19 Q. That's the same sentence that you included 20 in your declaration. Right? 21 A. That is. 22 Q. And the next sentence, two sentences</p>
<p style="text-align: right;">198</p> <p>1 You cited to Exhibit 2027. Right? 2 A. Exhibit 2027. 3 Q. You reviewed that entire exhibit before 4 citing it in your declaration. Correct? 5 A. I did. But I don't remember which one 6 that is. 7 Q. Okay. 8 (Exhibit 2027, previously marked, is not 9 attached to the transcript.) 10 Q. Do you recognize Exhibit 2027? 11 A. I do. 12 Q. You're familiar with this Pardi? 13 A. I am. Yes. Norbert. 14 Q. You included a quotation from this exhibit 15 in your declaration in Paragraph 72, and I'll just 16 read it. 17 You said or you included the quotation, 18 "These early promising results did not lead to 19 substantial investment in developing mRNA 20 therapeutics, largely owing to concerns associated 21 with mRNA instability, high immunogenicity, and 22 inefficient in vivo delivery." Right?</p>	<p style="text-align: right;">200</p> <p>1 later, rather, it continues, "Over the past 2 decade, major technological innovation and 3 research investment have enabled mRNA to become a 4 promising therapeutic tool in the fields of 5 vaccine development and protein replacement 6 therapy." Do you see that? 7 A. Yes. 8 Q. So fair to say that the Pardi publication 9 is reporting that between the years of 2008 and 10 2018, the date of its publication, there had been 11 major technological innovation and research 12 investment that had solved the concerns associated 13 with mRNA instability. Is that fair? 14 MR. PRUSSIA: Object to the form of the 15 question. 16 A. So the keywords here "over the past 17 decade," that there were major technological 18 advances. 19 So that -- and I understand where they're 20 going within this review article -- documents 21 various components and innovations that happened 22 at various times over the course of, say,</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 51 of 130

Conducted on August 2, 2024

<p style="text-align: right;">201</p> <p>1 approximately a decade. But all of those, every 2 single one of those had to come together to -- for 3 mRNA to eventually emerge, which was really -- and 4 start to show this new era of vaccinology as their 5 title. 6 So what they're referring to is really 7 innovations that even at the time may not have 8 envisioned -- been envisioned for use of an mRNA 9 vaccine may have happened ten years ago but at the 10 time they would not necessarily have envisioned 11 them being applied to mRNA vaccines. 12 It's kind of the way a lot of research 13 goes. We build on building blocks of others, and 14 then there would be multiple different innovations 15 that had to be combined, some of them more 16 contemporary with the paper, which is in 2018, to 17 bring mRNA vaccines to this point in 2018. People 18 were starting to see them as part of a new era in 19 vaccinology. 20 Q. This teaching in Pardi that "Over the past 21 decade, major technological innovation and 22 research investment enabled mRNA to become a</p>	<p style="text-align: right;">203</p> <p>1 you gave, which purports to state that you thought 2 about seven or eight years ago mRNA vaccines 3 started to take the lead and that researchers 4 solved a lot of the problems, notably the 5 instability, and discovered new technologies to 6 deliver mRNA into cells and ways of modifying the 7 coding sequence to make the vaccines a lot more 8 safe to use in humans. Do you see that portion? 9 A. Yes. I remember that portion. Yes. 10 Q. And that is entirely consistent with the 11 portion of Pardi that we just reviewed, isn't it? 12 MR. PRUSSIA: Object to the form, 13 reference to prior testimony on the document. 14 A. I actually think you kind of have helped 15 me to explain this, by bringing those two things 16 together, is that -- again, it's just referring 17 back to what I said before -- is that it's really 18 an accumulation of things over several years that 19 ultimately brought mRNA vaccines somewhere in the 20 zone around 2016, 2017, when they started to show 21 promise, and things even theoretically eight or 22 even ten years ago that might have been an</p>
<p style="text-align: right;">202</p> <p>1 promising therapeutic tool in the fields of 2 vaccine development" is consistent with the 3 statements that we saw in the article that we 4 discussed for me this morning that stated, 5 "Researchers solved a lot of the problems - 6 notably the instability - and discovered new 7 technologies to deliver mRNA into cells." 8 Correct? 9 MR. PRUSSIA: Object to the form. 10 A. So again, you're going to have to remind 11 me again which article you're referring to. 12 Q. It's 1100. It's this one right here. 13 A. The conversation? 14 Q. Yeah. 15 A. Okay. 16 Q. The article reflective of the 17 conversation. 18 A. Okay. And then you want to draw parallels 19 to -- 20 Q. I want to draw a parallel between the 21 conclusion that you draw or that's drawn in this 22 article, which was written after an interview that</p>	<p style="text-align: right;">204</p> <p>1 innovation in mRNA in general that were not 2 envisioned in terms of being applicable for mRNA 3 vaccines per se would have been eventually put 4 together by multiple different investigating teams 5 to arrive at a place where eventually mRNA 6 vaccines could be seen as promising. 7 Q. Okay. Going back to Pardi, let's turn to 8 page 262. 9 A. 262. Where am I? 10 Q. I know. We're getting lost here. It's 11 this one here, I believe. I handed you the wrong 12 one. 13 A. This one. 14 Q. Okay. At the bottom of page 262, the 15 bottom right-hand corner, do you see the heading 16 "Optimization of mRNA Translation and Stability"? 17 A. I see that. 18 Q. The second sentence under that heading 19 discusses the 5' and 3' UTR elements. Do you see 20 that? 21 A. I see that. 22 Q. It says that "the 5' and 3' UTR elements</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 52 of 130

Conducted on August 2, 2024

<p style="text-align: right;">205</p> <p>1 blanking the coding sequence profoundly influence 2 the stability and translation of mRNA." Right? 3 A. I see that. 4 Q. It says "both of which are critical 5 concerns for vaccines." Correct? 6 A. Stability, translation of mRNA. Yes. 7 Q. So stability and translation of mRNA are 8 both critical concerns -- 9 A. That's what they're referring to, I 10 believe. 11 Q. Is it fair to say that this teaches that 12 3' and 5' UTR elements of an mRNA sequence are 13 important to the performance of an mRNA vaccine? 14 A. They're summarizing, yeah, a lot of 15 evidence that suggests that those elements are 16 important. 17 Q. And if we go to the next page, page 263, 18 it continues, "5' cap structure is required for 19 efficient protein production from mRNA." Do you 20 see that? 21 A. I see that. 22 Q. Was that known by October 2015, that a</p>	<p style="text-align: right;">207</p> <p>1 of the question again. 2 Q. 5' caps function differently. 3 A. In the context of the mRNA -- expression 4 of protein by mRNA, it can. 5 Q. The next sentence of the Pardi 6 publication, which I think you have right in front 7 you, states that "The poly(A) tail also plays an 8 important regulatory role in mRNA translation and 9 stability; thus, an optimal link of poly(A) must 10 be added to mRNA either directly either from the 11 encoding DNA template or by using poly(A) 12 polymerase." Do you see that? 13 A. I see that. 14 Q. Was it known by 2015 that the poly(A) tail 15 also plays an important regulatory role in mRNA 16 translation? 17 A. It's pretty much standardized by then. 18 Q. And because there is an optimal link of 19 poly(A), different poly(A) tails can function 20 differently. Right? 21 MR. PRUSSIA: Object to the form. 22 A. Well, when we speak of optimal link, it</p>
<p style="text-align: right;">206</p> <p>1 5' cap structure is required for efficient protein 2 production from mRNA? 3 A. There was a lot of work on that, 4 particularly in the development of mRNA as a 5 therapeutic. That's where a lot of that came 6 from. 7 Q. There are various versions of 5' caps. 8 Right? 9 A. There are different versions that have 10 been tested that can be interchangeable in some 11 cases. 12 Q. Are they not interchangeable in some cases 13 as well? 14 A. I'm trying to think if I can think of an 15 example. I can't think of an example. 16 Q. Do different versions of 5' caps function 17 differently? 18 MR. PRUSSIA: Object to the form. 19 A. In the context of? 20 Q. mRNA vaccines. 21 MR. PRUSSIA: Same objection. 22 A. So do different versions of -- remind me</p>	<p style="text-align: right;">208</p> <p>1 doesn't go to the fact that there can be a 2 potential range in the optimal link, depending on 3 what particular nucleic acid structure you're 4 talking about. 5 Q. Is it your testimony that there need not 6 be an optimal link of poly(A) added to the mRNA? 7 I'm sorry. I just didn't understand that. 8 A. Anytime you create an expression cassette, 9 you standardize your poly(A) length. You 10 could . . . 11 So all of my steps, for example, have a 12 standardized poly(A) link. 13 Q. Let's go back to Paragraph 72 of your 14 declaration. 15 MR. PRUSSIA: Can we take a break, if 16 you're done? 17 MS. MAYS-WILLIAMS: Sure. 18 (Recess, 2:22 p.m. to 2:44 p.m.) 19 BY MS. MAYS-WILLIAMS: 20 Q. I'm handing you what's already been marked 21 as Exhibit 1009. Do you recognize this document? 22</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 53 of 130

Conducted on August 2, 2024

<p>209</p> <p>1 (Exhibit 1009, previously marked, is not 2 attached to the transcript.) 3 A. This is the Schrum. 4 Q. So we'll be in agreement we can refer to 5 this document as "Schrum" and we'll both know what 6 we're referring to? 7 A. That's right. 8 Q. You understand that in these proceedings, 9 BioNTech and Pfizer have alleged that the 10 challenged claims are invalid due to anticipation. 11 Right? 12 A. That's right. 13 Q. And as we discussed, your declaration 14 states that a reference anticipates a claim where 15 the prior art reference discloses each and every 16 limitation either expressly or inherently in a 17 single prior art reference. Right? 18 MR. PRUSSIA: Objection, incomplete. 19 A. Could you repeat that again? 20 Q. Your declaration states that a reference 21 anticipates a patent claim where the prior art 22 reference discloses each and every limitation</p>	<p>211</p> <p>1 Q. I think I'm reading exactly directly from 2 your declaration. Let's look at it together. 3 A. You're in the '127? 4 Q. The '127. 5 A. And that was which? 6 Q. Paragraph 22. 7 A. Okay. Go ahead. 8 Q. Actually, do you mind just reading that 9 first sentence into the record so that we're on 10 the same page about the standard that we're 11 applying for anticipation. I'm referring -- 12 A. "I have been informed that a patent claim 13 is invalid for anticipation only if each and every 14 limitation in the claim is disclosed either 15 expressly or inherently in a single prior art 16 reference. 17 "I understand that it is the patent 18 challenger's burden to prove that every limitation 19 in a challenged claim is found in the prior art 20 either inherently or explicitly." 21 Q. Okay. So you're familiar with Schrum? 22 A. I am.</p>
<p>210</p> <p>1 either expressly or inherently in a single prior 2 art reference. 3 MR. PRUSSIA: Same objection. 4 A. Could you point me to in my declaration 5 where you pulled that out of? 6 Q. It's Paragraph 22. 7 A. And what was your question again? 8 Q. Your declaration states that a reference 9 anticipates a patent claim if each and every 10 limitation in the claim is disclosed either 11 expressly or inherently in a single prior art 12 reference. 13 MR. PRUSSIA: Objection, incomplete. 14 A. Then I understand that it is the patent 15 challenger's burden to prove that every limitation 16 in a challenged claim was found in the prior art 17 either inherently or explicitly. And there's more 18 in terms of where that goes on there. This is 19 what I was -- yeah. 20 Q. Let me just make we're on the same page. 21 A. Are you reading something different than I 22 am?</p>	<p>212</p> <p>1 Q. Okay. Let's go to page or -- excuse me -- 2 Paragraph 340. Take a moment and just reread 3 Paragraph 340. 4 A. You want me to read that? 5 Q. To yourself, if you don't mind. And just 6 let me know when you're done. 7 A. I've read it. 8 Q. Okay. You don't dispute that Schrum 9 discloses an mRNA vaccine encoding an immunogen, 10 do you? 11 MR. PRUSSIA: Object to the form. 12 A. So what Schrum describes is the potential 13 to use mRNA vaccines, mRNA, to encode -- deliver 14 an immunogenic peptide or polypeptide. 15 But what Schrum doesn't do is provide any 16 examples of or any data supporting that statement 17 anywhere in the patent application. 18 Q. You don't dispute that Schrum discloses an 19 mRNA vaccine to elicit or provoke an immune 20 response. Right? 21 MR. PRUSSIA: Objection, asked and 22 answered.</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 54 of 130

Conducted on August 2, 2024

<p>213</p> <p>1 A. By 2013, it was pretty well known that you</p> <p>2 could do different nucleic acids and inject those</p> <p>3 into cells and those nucleic acids could express</p> <p>4 something and maybe provoke an immune response.</p> <p>5 So in generic language, I think to include</p> <p>6 if you're going to work on any sort of mRNA, to</p> <p>7 mention that, even though there's no specific</p> <p>8 examples or data to support that.</p> <p>9 I see that as -- as a POSA, I see that as</p> <p>10 a generic statement, not something that is</p> <p>11 actually being -- that I would take actually</p> <p>12 seriously.</p> <p>13 Q. And why would you not take it seriously?</p> <p>14 A. Because there's no data to back that up.</p> <p>15 Q. And is it your understanding that data is</p> <p>16 required for anticipation?</p> <p>17 A. Well, it is my understanding that data</p> <p>18 is -- is -- strengthens -- is important for --</p> <p>19 otherwise, you could say anything.</p> <p>20 Q. Is it your understanding that data is</p> <p>21 required for a reference to anticipate a patent</p> <p>22 claim?</p>	<p>215</p> <p>1 to me. So if you could repeat that again?</p> <p>2 Q. How are you able to offer an opinion as to</p> <p>3 whether a prior art reference anticipates a patent</p> <p>4 claim if you don't know whether data is required</p> <p>5 for anticipation?</p> <p>6 A. If I don't know if data is required for</p> <p>7 anticipation, then how can I offer an opinion?</p> <p>8 Q. As to whether this reference is</p> <p>9 anticipatory or not.</p> <p>10 A. What I can offer an opinion on is the --</p> <p>11 whether or not there's evidence to support a</p> <p>12 statement within a patent or not.</p> <p>13 Q. You offered an opinion that Schrum does</p> <p>14 not anticipate certain claims of the '600 and '127</p> <p>15 patents. Correct?</p> <p>16 A. And where in my declaration are you</p> <p>17 looking?</p> <p>18 Q. Are you aware of whether you offer an</p> <p>19 opinion about whether Schrum anticipates --</p> <p>20 A. But you're looking at my declaration, I</p> <p>21 think, so I want to be on the same page.</p> <p>22 Q. We'll get there. I just want to make sure</p>
<p>214</p> <p>1 A. So I think you're getting in a sort of</p> <p>2 legalese that I'm not familiar with, so in terms</p> <p>3 of what the rules are for making patents.</p> <p>4 Q. Is it fair to say that you're not sure</p> <p>5 whether data is required for a prior art reference</p> <p>6 to anticipate a patent claim?</p> <p>7 A. What I am sure of is that a patent that</p> <p>8 includes examples is a strong patent. I've filed</p> <p>9 and been an inventor on multiple patents myself,</p> <p>10 and incorporating data was absolutely central to</p> <p>11 make that a strong patent.</p> <p>12 Q. How were you able to offer an opinion as</p> <p>13 to whether a prior art reference anticipates a</p> <p>14 patent claim if you're unsure whether data is</p> <p>15 required for anticipation?</p> <p>16 A. You're going to have to run that by me</p> <p>17 again.</p> <p>18 Q. How are you able to offer an opinion as to</p> <p>19 whether a prior art reference anticipates a patent</p> <p>20 claim if you're unsure whether data is required</p> <p>21 for anticipation?</p> <p>22 A. I guess your question doesn't make sense</p>	<p>216</p> <p>1 that you have an understanding as to what your</p> <p>2 opinions are.</p> <p>3 A. I am.</p> <p>4 Q. Okay. Do you have an understanding as to</p> <p>5 whether you've offered any opinion regarding</p> <p>6 whether Schrum anticipates any claims at issue in</p> <p>7 these proceedings?</p> <p>8 A. I have offered an opinion.</p> <p>9 Q. And what is that opinion?</p> <p>10 A. Of whether Schrum independently offers any</p> <p>11 anticipation or Schrum in reference to other</p> <p>12 documents anticipates anything.</p> <p>13 Q. What is your opinion with regard to</p> <p>14 whether Schrum anticipates any claims at issue in</p> <p>15 these proceedings?</p> <p>16 A. My opinion on Schrum is that Schrum is a</p> <p>17 document that describes the use of mRNA for</p> <p>18 therapeutics, and it doesn't anticipate mRNA for</p> <p>19 vaccines. It offers examples on using mRNA for</p> <p>20 therapeutics.</p> <p>21 Q. What is a therapeutic that provokes an</p> <p>22 immune response in an organism, if not a vaccine?</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 55 of 130

Conducted on August 2, 2024

<p>217</p> <p>1 MR. PRUSSIA: Are you done with your prior</p> <p>2 answer?</p> <p>3 THE WITNESS: Yes.</p> <p>4 A. Excuse me?</p> <p>5 Q. What is a therapeutic that invokes an</p> <p>6 immune response in an organism, if not a vaccine?</p> <p>7 A. It could be a monoclonic antibody. It</p> <p>8 could be an mRNA expressing a monoclonic antibody</p> <p>9 in vivo, for example. So there are other</p> <p>10 therapeutics that could theoretically engage an</p> <p>11 immune response but not necessarily be a vaccine.</p> <p>12 Q. Vaccines do provoke immune responses in</p> <p>13 organisms. Correct?</p> <p>14 A. Other things as well provoke immune</p> <p>15 responses besides vaccines.</p> <p>16 Q. I want to go back to your understanding of</p> <p>17 the anticipation standard. You were talking about</p> <p>18 data and a lack of data in Schrum.</p> <p>19 Do you have any understanding as to</p> <p>20 whether a prior art reference can be an</p> <p>21 anticipatory reference without the inclusion of</p> <p>22 data or examples?</p>	<p>219</p> <p>1 towards production of protein and the amount of</p> <p>2 protein in vivo but not any examples that show</p> <p>3 vaccines that relate in any way to vaccines.</p> <p>4 Q. My question to you is whether you have any</p> <p>5 understanding whatsoever as to whether those</p> <p>6 examples are necessary for Schrum to anticipate</p> <p>7 the claims at issue in these proceedings?</p> <p>8 MR. PRUSSIA: Same objection, calls for a</p> <p>9 legal conclusion.</p> <p>10 Q. If you don't know, you can say you don't</p> <p>11 know.</p> <p>12 A. I thought I made that clear that I don't</p> <p>13 have the legal background to know what</p> <p>14 constitutes --</p> <p>15 What I can say as a POSA is that you would</p> <p>16 not -- a POSA would not look at the data or the</p> <p>17 information in Schrum and say that teaches them</p> <p>18 towards vaccines.</p> <p>19 Q. And your counsel didn't give you the legal</p> <p>20 information for you to know what constitutes an</p> <p>21 anticipatory reference. Is that fair?</p> <p>22 MR. PRUSSIA: You can note that I'm</p>
<p>218</p> <p>1 MR. PRUSSIA: Object to the form, calls</p> <p>2 for a legal conclusion.</p> <p>3 A. So if you can break that down to me</p> <p>4 without using -- so I'm not a patent attorney, so</p> <p>5 I think you're using legal terms that are outside</p> <p>6 of my understanding.</p> <p>7 Q. Is it fair to say that you don't know</p> <p>8 whether a reference can be anticipatory if it</p> <p>9 doesn't include data?</p> <p>10 MR. PRUSSIA: Same objections.</p> <p>11 Q. I'm not trying to trick you. You offered</p> <p>12 an opinion about whether this reference is</p> <p>13 anticipatory.</p> <p>14 A. Yes. And I explained to you what my</p> <p>15 opinion was. And it's not in my wheelhouse how</p> <p>16 that gets framed within legalese, so to speak.</p> <p>17 So my opinion is that Schrum is not</p> <p>18 anticipatory because it focuses on methods and</p> <p>19 technologies to -- for mRNA as a therapeutic, not</p> <p>20 as a vaccine. So it's not anticipatory for</p> <p>21 vaccines.</p> <p>22 It has only examples that are specific</p>	<p>220</p> <p>1 laughing.</p> <p>2 And I'll object to that and refer you to</p> <p>3 your section "Anticipation," Paragraphs 22, 23,</p> <p>4 and 24.</p> <p>5 Q. You can check those sections, but you're</p> <p>6 not going to find the answer.</p> <p>7 And I just want to know whether you have</p> <p>8 any understanding or if you don't. It's a fair</p> <p>9 question.</p> <p>10 MR. PRUSSIA: Same objection.</p> <p>11 A. All right. So I don't see that the</p> <p>12 anticipation or the information is anticipating in</p> <p>13 an adequate way that a POSA could practice it and</p> <p>14 that they would be able to derive everything from</p> <p>15 Schrum. All the elements do not come together to</p> <p>16 anticipate a vaccine.</p> <p>17 Q. Do you agree with me that the disclosure</p> <p>18 that we just discussed in Paragraph 340 of Schrum</p> <p>19 references eliciting or provoking an immune</p> <p>20 response in an organism with mRNA? Right?</p> <p>21 MR. PRUSSIA: Objection, asked and</p> <p>22 answered previously.</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 56 of 130

Conducted on August 2, 2024

<p>221</p> <p>1 A. Where are we again?</p> <p>2 Q. Paragraph 340.</p> <p>3 MR. PRUSSIA: To the extent the question</p> <p>4 is still pending, I have the same objection, asked</p> <p>5 and answered previously.</p> <p>6 MS. MAYS-WILLIAMS: It's still pending.</p> <p>7 Q. It's under the heading, just to help you.</p> <p>8 MS. MAYS-WILLIAMS: And for the record,</p> <p>9 it's under the heading "Activation of the Immune</p> <p>10 Response: Vaccines," Paragraph 340.</p> <p>11 A. Right. And my answer is essentially the</p> <p>12 same as what I said before.</p> <p>13 I guess maybe reask your question again.</p> <p>14 Maybe I'm not answering the right question.</p> <p>15 Q. The disclosure of Schrum in Paragraph 340</p> <p>16 under the heading "Activation of the Immune</p> <p>17 Response: Vaccines" states that mRNA may be used</p> <p>18 to elicit or provoke an immune response in an</p> <p>19 organism. Correct?</p> <p>20 A. So in -- I mean, this statement doesn't</p> <p>21 provide information in how it would be delivered.</p> <p>22 It doesn't provide any information on what immune</p>	<p>223</p> <p>1 formulating mRNA in a lipid nanoparticle, do you?</p> <p>2 A. And which paragraphs do you want me to go</p> <p>3 through in terms of looking at that? There's a</p> <p>4 whole list of different formulations,</p> <p>5 microspheres, liposomes, different sorts of</p> <p>6 formulations.</p> <p>7 Q. Go to Paragraph 8.</p> <p>8 A. So it's describing one aspect of</p> <p>9 formulation that -- one formulation of many that</p> <p>10 are listed in here.</p> <p>11 Q. It's describing many formulations for</p> <p>12 encapsulating mRNA in lipid nanoparticles. Is</p> <p>13 that fair?</p> <p>14 MR. PRUSSIA: Object to the form.</p> <p>15 A. There are a laundry list, basically a</p> <p>16 fairly long list here of different types of</p> <p>17 formulations that could be used.</p> <p>18 Q. One of those includes lipid nanoparticles.</p> <p>19 Right?</p> <p>20 A. So there are microspheres -- there's lipid</p> <p>21 nanoparticles, there's microspheres, several</p> <p>22 different types of formulations listed here.</p>
<p>222</p> <p>1 response. It doesn't provide information on what</p> <p>2 immunogen it would encode. It provides no</p> <p>3 information that would, in my mind, be</p> <p>4 anticipatory of the disputed patents.</p> <p>5 Q. One thing that elicits or provokes an</p> <p>6 immune response in an organism is a vaccine.</p> <p>7 Right?</p> <p>8 MR. PRUSSIA: Objection, asked and</p> <p>9 answered.</p> <p>10 A. So there are multiple things that can</p> <p>11 provoke an immune response in an organism.</p> <p>12 Q. A vaccine --</p> <p>13 A. A vaccine is just one of them. mRNA can</p> <p>14 encode a lot of other things other than immunogens</p> <p>15 in a vaccine and provoke an immune response.</p> <p>16 In fact, mRNA itself, even without</p> <p>17 encoding anything, can provoke immune response.</p> <p>18 And that's not a vaccine.</p> <p>19 Q. Go with me, please, to the beginning,</p> <p>20 page 1 of Schrum, Paragraphs 5, 6, and 7 -- and 8</p> <p>21 as well.</p> <p>22 You don't dispute that Schrum discloses</p>	<p>224</p> <p>1 Q. Maybe I can direct you to Paragraph 6,</p> <p>2 which states that in an embodiment the formulation</p> <p>3 comprising the modified mRNA is a nanoparticle</p> <p>4 which may comprise at least one lipid.</p> <p>5 A. Yeah. And so from there?</p> <p>6 Q. So you don't dispute that Schrum discloses</p> <p>7 formulating mRNA in a lipid nanoparticle. Right?</p> <p>8 MR. PRUSSIA: Object to the form, vague.</p> <p>9 A. So what Schrum is disclosing here are mRNA</p> <p>10 formulated in a nanoparticle comprising different</p> <p>11 types of lipids but is not limited to the whole</p> <p>12 list of lipids.</p> <p>13 So is that -- that's what I'm seeing. I'm</p> <p>14 not sure what your question is, though.</p> <p>15 Q. Nanoparticles comprising different types</p> <p>16 of lipids are lipid nanoparticles. Right?</p> <p>17 A. So nanoparticle can comprise different</p> <p>18 lipids. Yes.</p> <p>19 Q. And so you don't dispute that Schrum</p> <p>20 discloses formulating mRNA in a lipid</p> <p>21 nanoparticle. Right?</p> <p>22 MR. PRUSSIA: Same objections.</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 57 of 130

Conducted on August 2, 2024

<p>225</p> <p>1 A. So what I'm not disputing is that Schrum 2 discloses different formulations, of which one of 3 those could be a lipid nanoparticle. 4 Q. If you look at Paragraph 8, you don't 5 dispute that Schrum discloses formulating mRNA in 6 a lipid nanoparticle with a fusogenic lipid, a 7 cholesterol, and a PEG lipid. Correct? 8 A. So again, my take of this section is that 9 what this -- what's being discussed here is mRNA 10 formulated with different types of lipid-based 11 formulations, of which one would be a lipid 12 nanoparticle. 13 Q. Right. I'm asking a more specific 14 question now. 15 One of those lipid nanoparticles that's 16 disclosed in Schrum that can be used to formulate 17 modified mRNA can include a cationic lipid, a 18 fusogenic lipid, a cholesterol, and a PEG lipid. 19 Right? 20 A. So they're listing those formulations as 21 well as many other formulations -- possible 22 formulations for delivering mRNA.</p>	<p>227</p> <p>1 detected and measured in the blood and measures 2 the amount of protein that is being produced and 3 circulating in the blood. 4 Q. Is mCherry an example of a reporter 5 protein? 6 A. That's another example where you can . . . 7 Q. GFP is an example of a reporter protein? 8 A. GFP is a real good example of a reporter 9 protein. 10 Q. Luciferase is a reporter protein? 11 A. Luciferase is another example of a 12 reporter protein. 13 Q. Are reporter proteins typically associated 14 with providing any sort of therapeutic value? 15 A. So they are markers for what the levels -- 16 they are standardized markers that one uses to 17 demonstrate that a platform is able to deliver a 18 protein and express a protein at a given level. 19 So they are surrogate markers for true 20 therapeutics that would have a medical impact. 21 Q. A surrogate marker that would be 22 suggestive of what -- suggestive of whether a</p>
<p>226</p> <p>1 Q. And the molar ratio for the cationic 2 lipid, fusogenic lipid, cholesterol, and PEG lipid 3 in Schrum has an option for formulating modified 4 mRNA, can have a molar ratio of 50:10:38.5:1.5:3 5 in reference to cationic lipid, fusogenic lipid, 6 cholesterol, and PEG lipid. Right? 7 A. That's one option of several listed here. 8 Q. While we're talking about Schrum, are you 9 aware of a disclosure in Schrum regarding various 10 reporter proteins? 11 A. Could you point to me what section you're 12 referring to? 13 Q. While I'm getting there, do you know the 14 purpose of a reporter protein? 15 A. Yes. 16 Q. What is the purpose of a reporter protein? 17 A. Depending on what you're wanting to 18 develop the technology for, but generally the 19 reporter protein -- for example, in Schrum, which 20 would be primarily targeted at therapeutics. 21 An example of a good reporter protein 22 would be SEAP, which is something that can be</p>	<p>228</p> <p>1 therapeutic protein would be expressed. Right? 2 MR. PRUSSIA: Object to the form, calls 3 for a legal conclusion, outside the scope. 4 Go ahead. 5 A. So the purpose, really, of the markers are 6 primarily in the context of an experimental 7 approach where you may be wanting to optimize 8 conditions, whether that's formulation or dose. 9 They provide easily -- easy assays and 10 methodology that allows you to quantify things 11 more precisely so that you can fine-tune and 12 refine your technology. 13 So it's just basically a tool, but it is a 14 marker that then you could swap out, say, a 15 different sequencing coding, a true therapeutic to 16 test. 17 It doesn't necessarily mean you'll get the 18 same amount. You'd have to test that 19 particular -- each protein would have to be still 20 tested, but it's basically an experimental tool. 21 Q. Is it fair to say it's a predictive 22 experimental tool?</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 58 of 130

Conducted on August 2, 2024

<p>229</p> <p>1 MR. PRUSSIA: Object to the form.</p> <p>2 A. So prediction is something that's</p> <p>3 interesting because it's more of a prediction in</p> <p>4 the sense that if it didn't work at all or very</p> <p>5 low, then it's unlikely to work with a given</p> <p>6 therapeutic protein.</p> <p>7 But if it does work, it doesn't</p> <p>8 necessarily mean it's still going to work with</p> <p>9 that therapeutic protein because there's a lot of</p> <p>10 other things that could be associated with that</p> <p>11 particular protein.</p> <p>12 Q. Would it be associated with an increased</p> <p>13 likelihood of it working with a therapeutic</p> <p>14 protein?</p> <p>15 MR. PRUSSIA: Object to the form. Also,</p> <p>16 outside the scope.</p> <p>17 A. So I think you're getting into a domain of</p> <p>18 therapeutics that is a little bit outside my</p> <p>19 scope.</p> <p>20 Q. You seemed to know until counsel over</p> <p>21 there said "outside the scope."</p> <p>22 So go ahead, if you can.</p>	<p>231</p> <p>1 Q. Can you try again? Maybe I just missed</p> <p>2 it.</p> <p>3 MR. PRUSSIA: Same objections, asked and</p> <p>4 answered.</p> <p>5 Q. Why would one use a reporter protein in</p> <p>6 the development of a therapeutic protein?</p> <p>7 MR. PRUSSIA: Same objections, outside the</p> <p>8 scope, asked and answered.</p> <p>9 A. I feel like I've answered in terms of that</p> <p>10 particular question why you would use a reporter</p> <p>11 protein. I'm not really an expert on</p> <p>12 therapeutics, using DNA even for therapeutics. My</p> <p>13 expertise is mostly for vaccines.</p> <p>14 Q. High protein expression using a reporter</p> <p>15 protein would signal some level of expression of a</p> <p>16 therapeutic protein, wouldn't it?</p> <p>17 MR. PRUSSIA: Same objections, including</p> <p>18 as to scope.</p> <p>19 A. I'm not sure of your question.</p> <p>20 Q. The reason that a person uses a reporter</p> <p>21 protein to measure expression is so that they can</p> <p>22 know whether it makes sense to move on to the next</p>
<p>230</p> <p>1 MR. PRUSSIA: Same objections.</p> <p>2 A. So I'll just clarify what I said before is</p> <p>3 that it's basically a tool.</p> <p>4 It's sort of a plus or minus. If it does</p> <p>5 work, then it's sort of a green light to go to the</p> <p>6 next step, but it's not a guarantee that it's</p> <p>7 going to lead necessarily to success with a</p> <p>8 given -- everything in the end needs -- you need</p> <p>9 to do the experiment.</p> <p>10 It's a different protein. You get</p> <p>11 different sorts of proteins that -- therapeutic</p> <p>12 proteins would be entirely different, depending on</p> <p>13 how they're expressed, maybe where they go, things</p> <p>14 like that.</p> <p>15 Q. Why would one use a reporter protein if</p> <p>16 there's -- scratch that.</p> <p>17 Can you explain to me why one would use a</p> <p>18 reporter protein in the development of a</p> <p>19 therapeutic protein?</p> <p>20 MR. PRUSSIA: Object to the form, outside</p> <p>21 the scope.</p> <p>22 A. I think I explained that already.</p>	<p>232</p> <p>1 step in the therapeutic development. Correct?</p> <p>2 A. So the reason why you would use a reporter</p> <p>3 protein is to -- as a first step, let's say, an</p> <p>4 easily measurable tool, can you easily quantify</p> <p>5 it. There's assays, there's kits. They're easy</p> <p>6 to measure as a first step to see whether or not</p> <p>7 your platform that you're trying to use, in this</p> <p>8 case an mRNA, is able to produce the protein in</p> <p>9 vivo and that you're able to measure at technical</p> <p>10 levels.</p> <p>11 Q. Success with the reporter protein, would</p> <p>12 that signal success with the platform that you're</p> <p>13 trying to use, in this case mRNA?</p> <p>14 MR. PRUSSIA: Object to the form, outside</p> <p>15 the scope of the definition.</p> <p>16 Q. Would success with a reporter protein</p> <p>17 signal success with a therapeutic platform?</p> <p>18 MR. PRUSSIA: Object to the form, outside</p> <p>19 the scope of the declaration.</p> <p>20 A. I guess I'm trying to get at -- is there a</p> <p>21 place in my declaration that you want to direct me</p> <p>22 to --</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

Conducted on August 2, 2024

<p style="text-align: right;">233</p> <p>1 Q. In the context of mRNA and LNP reporter 2 systems, what, if anything, can one conclude about 3 expression of some other protein when using a 4 reporter protein? 5 MR. PRUSSIA: Object to the form, outside 6 the scope of the declaration. 7 A. I'm just not sure I'm comfortable 8 answering. I feel like I've answered all the 9 questions to the extent of my knowledge related to 10 this particular area, and I would just answer them 11 the same way as I've answered them before. 12 Q. Do you just not know? 13 A. I do know. 14 Q. Okay. Can you answer? 15 A. I did answer already. 16 Q. I changed my question a little bit. 17 In the context of mRNA and LNP reporter 18 systems, what, if anything, can one conclude about 19 expression of some other protein when using a 20 reporter protein? 21 MR. PRUSSIA: Object to the form, outside 22 the scope of the declaration, and it's vague.</p>	<p style="text-align: right;">235</p> <p>1 S protein that's in the context of a vaccine, I 2 would want to pursue a platform that has evidence 3 that it would stimulate a strong immune response 4 against that protein. 5 So using -- as I mentioned before, using 6 mRNA vaccines as a therapeutic guides a POSA in 7 the absolute opposite direction from the direction 8 you'd want them to go for a vaccine, they would 9 want to go for a vaccine. 10 Q. Okay. Let's go back to Schrum for a 11 minute. 12 Is it your opinion that Schrum doesn't 13 anticipate the claims of the '600 and '127 patents 14 because Schrum doesn't disclose a betacoronavirus 15 spike protein antigen? 16 A. It does not disclose betacoronavirus spike 17 protein antigen. That's correct. 18 Q. You're aware that a patent application or 19 patent can incorporate another application by 20 reference. Correct? 21 A. I am aware of that. 22 Q. Do you have any understanding as to what</p>
<p style="text-align: right;">234</p> <p>1 A. And then specifically what other protein? 2 Q. Okay. Let's say you have a disclosure of 3 G-CSF mRNA encapsulated in LNP. 4 A. Okay. 5 Q. Would that disclosure teach a POSA to make 6 an LNP encapsulated mRNA that expresses the 7 S protein? 8 MR. PRUSSIA: Object to the form, outside 9 the scope of any issue in this IPR. 10 Q. He's not instructing you not to answer, so 11 you do have to answer the question. 12 MR. PRUSSIA: I'm pretty close to 13 instructing her not to answer. 14 A. It would not. 15 MR. PRUSSIA: Sort of an invitation for 16 you to put some foundation as to the relevance to 17 the IPR. 18 A. It would not, primarily because the 19 primary objective in a therapeutic is to produce a 20 protein in the absence of stimulating an immune 21 response against it. 22 A POSA wanting to use an mRNA for</p>	<p style="text-align: right;">236</p> <p>1 is required for a patent application to 2 incorporate a second reference? 3 A. In terms of just referencing it? 4 Q. Do you have any understanding whatsoever 5 as to what is required for a patent application to 6 incorporate another reference? 7 A. It needs to refer to it somewhere in the 8 text, I would imagine. 9 Q. Would you agree that Schrum refers to 10 Geall in the text and incorporates it by 11 reference? 12 A. So if you could point me to where that is. 13 Q. Paragraph 342. Do you see where it says, 14 "As another nonlimiting example, the modified 15 nucleic acid molecules, mRNA, of the present 16 invention encoding an immunogen may be delivered 17 to a vertebrate in a dose amount large enough to 18 be immunogenic to the vertebrate," and then it 19 references some publications there. Do you see 20 that? 21 A. Are we looking at the same thing? What 22 paragraph is that?</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

Conducted on August 2, 2024

<p>237</p> <p>1 Q. 342.</p> <p>2 A little bit further down. The middle of</p> <p>3 the Paragraph 342.</p> <p>4 A. Right. So as I stated in my declaration,</p> <p>5 what that is referring to is referencing that</p> <p>6 patent with regard to a dose.</p> <p>7 So it says "may be delivered to a</p> <p>8 vertebrate in a dose amount large enough to be</p> <p>9 immunogenic to the vertebrate."</p> <p>10 And in the patent it refers to, which is</p> <p>11 the Geall patent, they talk about different doses</p> <p>12 of self-amplifying RNA that could be administered</p> <p>13 to provoke an immune response.</p> <p>14 So that is self-amplifying RNA that</p> <p>15 they're referring to, and it's just a dose.</p> <p>16 Q. You do see, though, that it says that the</p> <p>17 Geall reference is incorporated by reference in</p> <p>18 its entirety. Do you see that?</p> <p>19 A. I do see that. Yes.</p> <p>20 Q. But you only take that as to incorporation</p> <p>21 of Geall for the dose amounts. Correct?</p> <p>22 A. As a POSA reading this, if I were reading</p>	<p>239</p> <p>1 to direct you to the whole shebang but really to</p> <p>2 what is actually described right there, which is</p> <p>3 the dose.</p> <p>4 (Exhibit 1010, previously marked, is not</p> <p>5 attached to the transcript.)</p> <p>6 Q. I'm handing you what's been marked</p> <p>7 previously as Exhibit 1010. You have reviewed</p> <p>8 Geall previously. Correct?</p> <p>9 A. That's right.</p> <p>10 Q. And you reviewed it in forming your</p> <p>11 opinions --</p> <p>12 A. That's right.</p> <p>13 Q. -- provided in your declaration?</p> <p>14 You would agree with me, wouldn't you,</p> <p>15 that Geall does, in fact, disclose RNA vaccines</p> <p>16 encoding a betacoronavirus spike protein. Right?</p> <p>17 A. I don't agree with that.</p> <p>18 What Geall talks about here is a</p> <p>19 self-amplifying RNA platform with RSV F protein,</p> <p>20 is my recollection.</p> <p>21 Q. Would you go with me to page 19, please.</p> <p>22 A. Page 19.</p>
<p>238</p> <p>1 this patent, I would read it just like I would a</p> <p>2 manuscript. And when I see something that ends</p> <p>3 and says "in doses large enough" and then</p> <p>4 something in parentheses, I understand that they</p> <p>5 are directing me to that to learn what dosing</p> <p>6 would be sufficient.</p> <p>7 Q. And what's your basis for disregarding the</p> <p>8 remaining portion of Geall, despite the fact that</p> <p>9 it's explicitly incorporated by reference in the</p> <p>10 Schrum document here?</p> <p>11 MR. PRUSSIA: Object to the form, asked</p> <p>12 and answered.</p> <p>13 A. So when I read a manuscript and I see, as</p> <p>14 I mentioned, something in parentheses in a</p> <p>15 statement and something comes after that</p> <p>16 parentheses and it's referring -- in this case, it</p> <p>17 says "in a dose large enough to be immunogenic in</p> <p>18 a vertebrate," it gives a reference, I'm going to</p> <p>19 go to the reference for the dose.</p> <p>20 Now, if this was a manuscript, the entire</p> <p>21 manuscript is referenced. That doesn't</p> <p>22 necessarily mean that the intent of the author is</p>	<p>240</p> <p>1 Q. At the bottom of page 19, do you see the</p> <p>2 word "coronavirus"?</p> <p>3 A. Yes.</p> <p>4 Q. Actually, back up.</p> <p>5 A. I wanted to get the context of where this</p> <p>6 is. Oh, I see. This is the laundry list of</p> <p>7 pathogens.</p> <p>8 Q. The list of pathogens starts at the bottom</p> <p>9 of page 15, and you see the heading there "The</p> <p>10 Immunogen"?</p> <p>11 A. Yes. This is the laundry list of</p> <p>12 different candidate immunogens. Yes.</p> <p>13 Q. It says, "RNA molecules are used with the</p> <p>14 invention to encode the polypeptide immunogen and</p> <p>15 after administration of the RNA the immunogen is</p> <p>16 translated in vivo and can elicit an immune</p> <p>17 response in the recipient. The immunogen may</p> <p>18 elicit an immune response against a bacterium, a</p> <p>19 virus, a fungus, or parasite." Right?</p> <p>20 A. I read all of that. Yes, I see that.</p> <p>21 Q. And it continues at the top of the next</p> <p>22 page. "The immune response may comprise an</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 61 of 130

Conducted on August 2, 2024

<p style="text-align: right;">241</p> <p>1 antibody response usually including IgG and/or a 2 cell-mediated immune response. The polypeptide 3 immunogen will typically elicit an immune response 4 which recognizes the corresponding bacterial, 5 viral, fungal, or parasite or allergen or tumor 6 polypeptide." Do you see that? 7 A. I see all of that. 8 Q. And then it says, "The immunogen will 9 typically be a surface polypeptide, e.g., among 10 other things a spike glycoprotein." Right? 11 A. Yes. 12 Q. And then at the bottom of page 19, do you 13 see where it says "coronavirus"? 14 A. Yes, I see that. 15 Q. And it says that "Viral immunogens include 16 but are not limited to those derived from a SARS 17 coronavirus." Correct? 18 A. I read that. Yes. 19 Q. And it says that "the coronavirus 20 immunogen may be a spike polypeptide." 21 A. I see "spike polypeptide." Right. 22 Q. We've established today that a SARS</p>	<p style="text-align: right;">243</p> <p>1 want to refer to a linear peptide, we are going to 2 call it peptide or polypeptide. 3 Q. But you'd agree with me that spike 4 polypeptide can include spike protein. Correct? 5 A. Technically speaking, it could. 6 But it's not -- it's very generic and it's 7 not specific at all. So you wouldn't know from 8 reading that what was meant by "spike 9 polypeptide." 10 Q. You're aware that BioNTech and Pfizer have 11 argued that the claims of the '600 and '127 patent 12 in these proceedings would be obvious to a person 13 of ordinary skill in the art as of October 15 -- 14 or 2015. Correct? 15 A. I understand that's the issue. That's the 16 question that is being addressed here today. 17 Q. And you understand specifically that 18 BioNTech and Pfizer have argued that the claims at 19 issue in these proceedings would have been obvious 20 to a POSA in view of a few different combinations 21 of references. Right? 22 A. I understand that the -- that what they're</p>
<p style="text-align: right;">242</p> <p>1 coronavirus is a betacoronavirus. Correct? 2 A. It is. 3 Q. And this Geall article specifically 4 discloses that an immunogen can be a spike 5 protein. Correct? 6 MR. PRUSSIA: Objection. 7 A. I disagree. It says that the immunogen 8 may be a spike polypeptide. 9 Q. What's the difference between a spike 10 polypeptide and a spike protein? 11 A. There can be considerable differences. 12 A spike polypeptide is a more generic form 13 that can be linear sequences. A protein always 14 refers to something that's generally a full-length 15 protein or a subunit that has structure. 16 Q. A spike polypeptide is more generic but 17 would include spike protein. Correct? 18 A. It could. But in my field when we say 19 "polypeptide," we are generally referring 20 primarily to linear sequences. 21 If we want to refer to a structured 22 protein, we're going to call it a protein. If we</p>	<p style="text-align: right;">244</p> <p>1 looking for is to take bits and pieces from a 2 variety of different documents, patents, papers, 3 and the like and combine them in such a way to say 4 that that combination would be obvious to a POSA. 5 Q. The references that BioNTech and Pfizer 6 rely on are Schrum in view of Geall, Schrum in 7 view of Yang, and Schrum in view of Altmeyer. 8 Correct? 9 A. Those are the ones that I believe that are 10 being combined. 11 And as I state in my declaration, I 12 disagree that that combination of things would 13 have been something a POSA would look at and be 14 able to derive the invention. 15 Q. At page 208 of your declaration -- I'm 16 looking at the '127 declaration -- you say, "The 17 petitioners have not shown that a POSA would have 18 a motivation to combine Schrum and Geall with a 19 reasonable expectation of success to arrive at 20 Claim 1 of the '127 patent." Right? 21 A. Right. And that's based on Schrum is 22 primarily focused on therapeutics, mRNA for</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 62 of 130

Conducted on August 2, 2024

<p style="text-align: right;">245</p> <p>1 therapeutics, which you would not want to generate 2 an immune response. 3 So it would teach a POSA to -- actually 4 away from vaccines in that case. 5 Geall is talking about self-amplifying 6 RNA, which is not mRNA. And Geall has a whole 7 list of different pathogens that could be used, 8 provides really only data for one pathogen that's 9 RSV -- for RSV with the F protein. 10 And so in my estimation, a POSA, when you 11 combine those together, would have an -- almost 12 thousands of different options to choose from to 13 try to come up with the precise composition that 14 is in the '600 and '127 patents. 15 Q. I want to focus for a moment on this 16 "motivation to combine" language that you've 17 included in your declaration. 18 What does "motivation to combine" mean to 19 you? 20 A. So that would mean that they would have a 21 reasonable thinking that combining that would lead 22 to success, Number 1.</p>	<p style="text-align: right;">247</p> <p>1 (Recess, 3:36 p.m. to 3:52 p.m.) 2 BY MS. MAYS-WILLIAMS: 3 Q. So before we took a break, I was turning 4 to page 269 of your declaration. 5 A. Okay. 6 Q. When you get there, I want to direct your 7 attention to Paragraph 610. 8 A. Uh-hmm. 9 Q. In Paragraph 610, you discuss a reference, 10 the Vennema reference. 11 A. Uh-hmm. 12 Q. Are you familiar with the Vennema 13 reference? 14 A. Yes. 15 Q. Now, you noted in your declaration that 16 the Vennema reference related to a viral vector 17 vaccine. Is that correct? 18 A. That would be -- I don't remember which 19 viral vector vaccine, but yeah. 20 Q. It was a viral vector vaccine encoding the 21 S protein. Correct? 22 A. Right.</p>
<p style="text-align: right;">246</p> <p>1 And Number 2, that the state of the field 2 at the time would compel a POSA to want to 3 actually study that or investigate. There was 4 something going on or the state of the field is 5 such that it would be an attractive thing for a 6 POSA to want to pursue. 7 Q. Is it your testimony that a POSA would not 8 have been motivated to develop a betacoronavirus 9 vaccine based on the spike protein? 10 A. That is not my testimony. 11 But it is my testimony that a POSA would 12 not -- would have been cautious about pursuing the 13 S protein because of evidence -- because the 14 evidence for enhancement of disease that had been 15 noted with prior vaccines for SARS-CoV and MERS -- 16 so a POSA would not necessarily have assumed 17 success with the S protein without undue 18 experimentation. 19 Q. Could you go to Paragraph 610. 20 A. After this, if I could take -- I just have 21 to use the restroom. 22 Q. Let's take a break now.</p>	<p style="text-align: right;">248</p> <p>1 Q. It was not an mRNA vaccine formulated from 2 a lipid nanoparticle. Right? 3 A. In this experiment, no, it was not an mRNA 4 vaccine. 5 Q. Can you explain to me why Vennema's 6 discussion of a viral vector vaccine was relevant 7 to the choice of antigen to be encoded in an mRNA 8 vaccine formulated in a lipid nanoparticle? 9 A. So it's one example. It is one vaccine 10 platform that focused on the S protein and 11 observed evidence of enhanced disease when the 12 full-length S protein is used. 13 There were other vaccine modalities, such 14 as an inactivated vaccine, that the same sort of 15 thing was observed. 16 So this -- when you have multiple 17 different vaccine modalities exhibiting a similar 18 sort of effect with a single type of immunogen, 19 then it raises the question in an investigator 20 POSA's mind as to whether S protein may be a 21 specific immunogen that could enhance disease when 22 used in the context of a vaccine, any vaccine.</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 63 of 130

Conducted on August 2, 2024

<p>249</p> <p>1 Q. But why was the viral vector vaccine</p> <p>2 platform relevant to the mRNA vaccine platform?</p> <p>3 A. As I --</p> <p>4 MR. PRUSSIA: Objection, asked and</p> <p>5 answered.</p> <p>6 A. I already explained that, that it was one</p> <p>7 vaccine platform out of others that discussed that</p> <p>8 where an S protein was used and consistently</p> <p>9 pointed to the S protein being associated with</p> <p>10 enhanced disease in certain models.</p> <p>11 Q. So it's fair to say that information from</p> <p>12 viral vector vaccine platforms can be relevant to</p> <p>13 other vaccine platforms such as mRNA vaccine</p> <p>14 platforms. Correct?</p> <p>15 MR. PRUSSIA: Objection, mischaracterizes.</p> <p>16 A. That mischaracterizes. That is not</p> <p>17 exactly what I said.</p> <p>18 Q. You cite Vennema as the first article</p> <p>19 under the heading of "Exploration of Other</p> <p>20 Betacoronavirus Antigens." It's on page 269.</p> <p>21 A. There we are. Yes.</p> <p>22 Q. And Exhibit 2029 is "Early death after</p>	<p>251</p> <p>1 was pretty well established, to the point that</p> <p>2 when the COVID-19 vaccines were being developed</p> <p>3 there was concern among all the developers about</p> <p>4 the potential for using S protein for SARS-CoV-2,</p> <p>5 that it might also result in enhanced disease.</p> <p>6 So if you look at all the preclinical</p> <p>7 experiments with SARS-CoV-2 vaccines, including</p> <p>8 the mRNA vaccines from Moderna as well as Pfizer,</p> <p>9 they all addressed one or more figures of analysis</p> <p>10 of the types of immune responses that by then were</p> <p>11 known to be associated with enhanced disease.</p> <p>12 So that was pretty well known in the field</p> <p>13 that S protein, especially with coronaviruses,</p> <p>14 including betacoronaviruses, there was a potential</p> <p>15 risk of enhancement and infection.</p> <p>16 Q. And you were aware of that potential risk</p> <p>17 of infection when you made your selection in the</p> <p>18 development of your own SARS-CoV-2 vaccine</p> <p>19 candidates. Right?</p> <p>20 A. And you're referring to the Science</p> <p>21 Translational Medicine paper, Exhibit 1099?</p> <p>22 Q. That's it. Yup.</p>
<p>250</p> <p>1 feline infectious peritonitis vaccine challenge</p> <p>2 due to recombinant vaccinia virus immunization."</p> <p>3 Right?</p> <p>4 A. Where are you reading it? Are you</p> <p>5 referring to the reference?</p> <p>6 Q. I'm referring to the reference.</p> <p>7 And you can find the title of the</p> <p>8 reference in Appendix B, page 3 of the appendix.</p> <p>9 A. Uh-hmm.</p> <p>10 Q. FPIV is not a betacoronavirus, is it?</p> <p>11 A. So PAIV is a coronavirus.</p> <p>12 Q. Is it a betacoronavirus?</p> <p>13 A. It is -- this one is not a</p> <p>14 betacoronavirus.</p> <p>15 Q. Okay.</p> <p>16 A. But is one example of many that we listed</p> <p>17 within the context of this, including others</p> <p>18 that -- there were others I could have listed, for</p> <p>19 example SARS-CoV inactivated vaccine tested in</p> <p>20 nonhuman primates that resulted in enhanced</p> <p>21 disease.</p> <p>22 And just a list of other ones where this</p>	<p>252</p> <p>1 A. Yes. We were aware of that.</p> <p>2 And so if you look at Figure 2, because we</p> <p>3 knew that -- were aware of the prior research</p> <p>4 demonstrating the S protein and when used in the</p> <p>5 context of a vaccine could potentially enhance</p> <p>6 disease, we performed this experiment to assess</p> <p>7 the T helper bias associated with our vaccine.</p> <p>8 We knew from prior research that Th2 type</p> <p>9 immune responses had been associated with enhanced</p> <p>10 infection when used with the S protein. And we</p> <p>11 knew that Th1 type of responses were associated</p> <p>12 with lack of enhanced disease.</p> <p>13 So we wanted to -- in this experiment we</p> <p>14 investigated and demonstrated that our vaccine was</p> <p>15 driving more a Th1 type response.</p> <p>16 I would add by 2020 there were two things</p> <p>17 pretty well established, what were the mechanisms,</p> <p>18 potential mechanisms of enhanced disease</p> <p>19 associated with S protein.</p> <p>20 Those mechanisms weren't fully known in</p> <p>21 2015. It was known that there was incidences or</p> <p>22 reports of enhanced disease but not necessarily --</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 64 of 130

Conducted on August 2, 2024

<p style="text-align: right;">253</p> <p>1 the mechanisms were not known.</p> <p>2 So by 2020 when everybody was developing</p> <p>3 COVID-19 vaccines, it was clear that Th2 responses</p> <p>4 are not something you wanted your vaccine to</p> <p>5 induce.</p> <p>6 But the other variable to that is by 2020,</p> <p>7 but not in 2015, by 2020 we knew that RNA and DNA</p> <p>8 vaccines and nucleic vaccines in general drove</p> <p>9 more of a Th1 type of immune response.</p> <p>10 So we had even going into this paper some</p> <p>11 confidence even before doing this experiment that</p> <p>12 it would be likely driving more of a Th1 type of</p> <p>13 immune response.</p> <p>14 If you look in all of the COVID-19 vaccine</p> <p>15 preclinical studies similar to ours, including</p> <p>16 Moderna and Pfizer's mRNA vaccine preclinical</p> <p>17 studies in animal models, they all have one or</p> <p>18 more figures addressing the same question as to</p> <p>19 whether the vaccine is inducing a Th1 or Th2</p> <p>20 response.</p> <p>21 Because at that point we were still all</p> <p>22 concerned about the potential that S protein could</p>	<p style="text-align: right;">255</p> <p>1 asked you some questions about the level of immune</p> <p>2 response that's required by the claims. Do you</p> <p>3 remember that?</p> <p>4 A. I do remember that. Yeah.</p> <p>5 Q. And specifically, she pointed you to the</p> <p>6 language "an effective amount to induce in the</p> <p>7 subject an immune response to the BetaCoV</p> <p>8 S protein or S protein subunit." Do you see that?</p> <p>9 MS. MAYS-WILLIAMS: Objection to the form.</p> <p>10 A. I do see that.</p> <p>11 MS. MAYS-WILLIAMS: Could you slow down a</p> <p>12 minute so that I have an opportunity to object?</p> <p>13 Q. She gets to object.</p> <p>14 A. Okay.</p> <p>15 Q. So what does the patent -- you've reviewed</p> <p>16 the specification of the '127 patent. Right?</p> <p>17 A. I have.</p> <p>18 Q. What does the patent teach regarding the</p> <p>19 level of protectiveness provided by the mRNA, LNP,</p> <p>20 betacoronavirus vaccine as exemplified by the MERS</p> <p>21 vaccine candidate?</p> <p>22 MS. MAYS-WILLIAMS: I object to the form</p>
<p style="text-align: right;">254</p> <p>1 enhance disease but had some degree of confidence,</p> <p>2 depending upon your vaccine platform, that it</p> <p>3 would be okay.</p> <p>4 (Off the record, 4:00 p.m. to 4:03 p.m.)</p> <p>5 MS. MAYS-WILLIAMS: I actually pass the</p> <p>6 witness.</p> <p>7 MR. PRUSSIA: Okay. I'll need a break.</p> <p>8 Let's take a break. Thank you.</p> <p>9 (Recess, 4:04 p.m. to 4:24 p.m.)</p> <p>10 EXAMINATION BY COUNSEL FOR</p> <p>11 PATENT OWNER MODERNATX</p> <p>12 BY MR. PRUSSIA:</p> <p>13 Q. Dr. Fuller, I'm going to ask you some</p> <p>14 questions on redirect. Is that okay?</p> <p>15 A. Okay.</p> <p>16 Q. So you were asked some questions earlier</p> <p>17 today about Claim 1 of the '127 patent. Do you</p> <p>18 remember that?</p> <p>19 A. Yes.</p> <p>20 Q. Do you want to pull that out?</p> <p>21 A. Let me find that. There it is.</p> <p>22 Q. And in particular, counsel for petitioners</p>	<p style="text-align: right;">256</p> <p>1 of the question.</p> <p>2 A. So this particular patent teaches, you</p> <p>3 know, through its examples, both in a mouse study</p> <p>4 as well as in a rabbit study, that the mRNA</p> <p>5 vaccine, the MERS mRNA vaccine described in this</p> <p>6 application elicited sufficient neutralizing</p> <p>7 antibodies that they saw significant protection in</p> <p>8 the form of reduction of viral loads in vaccinated</p> <p>9 animals as compared to the control animals.</p> <p>10 So my understanding, of course, is that</p> <p>11 the -- and now I recall I described that being a</p> <p>12 protective immune response is what I was referring</p> <p>13 to -- is really the level of immunity one would</p> <p>14 need to see to achieve protective levels.</p> <p>15 And that is as exemplified in the data</p> <p>16 that was shown in this particular patent, which is</p> <p>17 about, you know a vaccine.</p> <p>18 And so the goal of any vaccine, of course,</p> <p>19 is to induce protective immunity. It's important,</p> <p>20 then, in developing a vaccine or patenting one</p> <p>21 that you are able to show that your platform is</p> <p>22 able to induce not only just an immune response</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 65 of 130

Conducted on August 2, 2024

<p style="text-align: right;">257</p> <p>1 but of sufficient levels to afford protection in a 2 verified animal model of that disease. 3 Q. So with reference to Claim 1, what level 4 of immune response would a person of ordinary 5 skill in the art reading that claim understand to 6 be required? 7 A. So they would understand it would have to 8 be a level of neutralizing antibody that would 9 correlate with a statistically significant 10 reduction in viral load in an animal model. 11 Q. So if you want to go back -- shifting 12 gears, you were asked some questions about 13 Exhibit 1101, if you want to pull that out. 14 This is one of the exhibits that counsel 15 for petitioners marked today. 16 A. This would be the evaluation candidate 17 vaccine approaches for MERS-CoV and specifically 18 the DNA vaccine for MERS. 19 Q. Okay. And do you recall being asked some 20 questions about this article earlier today by 21 counsel for petitioners? 22 A. Yes, I do.</p>	<p style="text-align: right;">259</p> <p>1 primings with DNA followed by a protein booster to 2 a protein immunization by itself. 3 And what is seen is that the heterologous 4 prime boost regimen resulted in high antibody 5 titers, on par with just the protein immunization, 6 and that the DNA immunization three times resulted 7 in much lower immune responses. 8 And that's consistent with my experience 9 with DNA and recombinant protein vaccines, that 10 when you combine them together you're going to get 11 a much more robust immune response. 12 What was included here was the comparison 13 of full-length S protein to an S protein with a -- 14 the transmembrane deleted and then the S1 subunit. 15 And this is a group that had actually 16 developed the S delta transmembrane version of the 17 spike protein. Because in previous studies this 18 group had observed, as well as were concerned 19 because of the prior research demonstrating that 20 full-length S could potentially result in enhanced 21 disease. 22 They generated this truncated version.</p>
<p style="text-align: right;">258</p> <p>1 Q. And just to level set, what vaccine 2 technology does this article discuss? 3 MS. MAYS-WILLIAMS: Objection to the 4 question. 5 A. So there are three different vaccine 6 platforms that were experimented here in this 7 paper, a DNA vaccine, which is of course not an 8 mRNA vaccine, and a protein vaccine, which is of 9 course not an mRNA vaccine. 10 And then in the year that this was 11 published, in 2015, one of the most popular 12 strategies to achieve robust immunogenicity was to 13 combine DNA vaccines with recombinant proteins in 14 a DNA prime and recombinant protein boost 15 immunization. 16 By 2015, it was pretty well established 17 that when you combine those two together in a 18 prime boost you're going to usually get a lot 19 higher antibody responses or immune responses than 20 either vaccine modality could induce by itself. 21 So what is shown, for example, in 22 Figure 1B is a comparison of DNA alone to two</p>	<p style="text-align: right;">260</p> <p>1 The spike protein is a strategy to block out the 2 types of antibodies that would be associated with 3 that enhanced disease; in other words, those 4 antibodies that were targeting potentially the 5 transmembrane region. And that was facilitating 6 enhanced disease. 7 And that's one that they had tested in 8 here. 9 In this figure, they ended up showing the 10 full-length spike protein not surprisingly 11 actually induced higher antibody titers than the 12 truncated version. And that's not surprising 13 because it is going to -- the full-length 14 S protein will have more epitopes, neutralizing 15 antibody epitopes to target. 16 But again, it was a concern about enhanced 17 disease because those additional antibodies may be 18 bad antibodies and contribute to enhanced disease. 19 So in this comparison when you see higher 20 antibodies against the full S protein, it's not 21 the whole story. 22 The whole story is that they eventually</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 66 of 130

Conducted on August 2, 2024

<p style="text-align: right;">261</p> <p>1 brought the study -- the delta TM, the delta</p> <p>2 transmembrane vaccine is one that they continued</p> <p>3 to develop because it's one that elicited</p> <p>4 sufficient neutralizing antibodies, especially</p> <p>5 when combined with recombinant protein booster</p> <p>6 immunizations, without the potential risk of</p> <p>7 inducing the types of antibodies that could</p> <p>8 increase the risk of enhanced disease.</p> <p>9 Q. So you mentioned this, but just to be</p> <p>10 clear, ultimately when this group brought a</p> <p>11 betacoronavirus vaccine into the clinic, was it a</p> <p>12 full-length spike protein or something else?</p> <p>13 A. It was not. It was a truncated version of</p> <p>14 a full-length spike protein.</p> <p>15 And based on the body of literature that</p> <p>16 they had developed -- shown with coronaviruses</p> <p>17 from Barney Graham's group, that they had studied</p> <p>18 a number of different things that were known, that</p> <p>19 they had evidence that the full-length S protein</p> <p>20 when administered as a protein-based vaccine could</p> <p>21 enhance infection.</p> <p>22 So they developed the truncated S protein.</p>	<p style="text-align: right;">263</p> <p>1 and study further due to the enhancement of the</p> <p>2 disease. So if they would learn anything it's</p> <p>3 that they would learn that maybe a DNA vaccine</p> <p>4 might be the way to go instead of a messenger RNA</p> <p>5 vaccine.</p> <p>6 Q. Okay. You can put that to the side.</p> <p>7 And speaking of data, do you recall being</p> <p>8 asked some questions this afternoon about whether</p> <p>9 an mRNA LNP system expressing a reporter protein</p> <p>10 would allow a person of skill in the art to draw</p> <p>11 conclusions regarding expression of an mRNA LNP</p> <p>12 system that could enforce spike protein?</p> <p>13 A. Right.</p> <p>14 Q. When you were asked those questions by</p> <p>15 counsel for petitioners, were you provided any</p> <p>16 data on the expression levels of the reporter</p> <p>17 protein in the mRNA LNP system?</p> <p>18 MS. MAYS-WILLIAMS: I object to the form</p> <p>19 of the question.</p> <p>20 A. No, I was not.</p> <p>21 Q. So just to be clear, when you were</p> <p>22 providing answers to those questions from counsel</p>
<p style="text-align: right;">262</p> <p>1 I would add that Barney Graham's group was</p> <p>2 at the time most of the focus on recombinant</p> <p>3 protein vaccines, but I think that they were doing</p> <p>4 this particular experiment because in 2015 this</p> <p>5 whole idea of combining their protein with a DNA</p> <p>6 priming and seeing potentially synergy was very</p> <p>7 appealing. It was sort of a state of the art of</p> <p>8 the day.</p> <p>9 Q. So what conclusions would a person of</p> <p>10 ordinary skill in the art draw from the results</p> <p>11 shown in Figure 1 of Exhibit 1101, regarding the</p> <p>12 effectiveness of an mRNA LNP vaccine encoded for a</p> <p>13 betacoronavirus S protein?</p> <p>14 A. So this is DNA. So there would not be any</p> <p>15 conclusions about how -- about mRNA vaccine based</p> <p>16 on these data.</p> <p>17 A POSA would have to investigate that -- a</p> <p>18 POSA would follow the full body of literature</p> <p>19 related to this particular study.</p> <p>20 They would end up finding that the</p> <p>21 truncated version of the spike protein was the one</p> <p>22 that was favored by this group to advance further</p>	<p style="text-align: right;">264</p> <p>1 for petitioners, you had no benefit of data.</p> <p>2 Correct?</p> <p>3 MS. MAYS-WILLIAMS: I object to the form</p> <p>4 of the question.</p> <p>5 A. I did not. I didn't have any benefit of</p> <p>6 data, and I think that's what confused me.</p> <p>7 And basically, my answer was it really</p> <p>8 kind of depended on what the expression looked</p> <p>9 like in terms of what you could do with that</p> <p>10 information in terms of expression, say, of a</p> <p>11 therapeutic, of something that would be of medical</p> <p>12 benefit.</p> <p>13 Q. So if there was such data with an mRNA LNP</p> <p>14 system involving expression of a reporter protein,</p> <p>15 with that data, the data that counsel did not show</p> <p>16 you, would that data be relevant to draw</p> <p>17 conclusions about the applicability of that mRNA</p> <p>18 LNP system to a betacoronavirus vaccine?</p> <p>19 MS. MAYS-WILLIAMS: I object to the form</p> <p>20 of the question.</p> <p>21 A. In my opinion, it would not be because the</p> <p>22 objective of a reporter such as SEAP and the like</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 67 of 130

Conducted on August 2, 2024

<p>265</p> <p>1 is really along the lines of a therapeutic.</p> <p>2 And again, as I had mentioned in my</p> <p>3 discussion earlier is that systems that are</p> <p>4 designed to optimize for a therapeutic -- in other</p> <p>5 words, a replacement of a protein or a production</p> <p>6 of max amount of protein -- are designed to</p> <p>7 primarily maximize the amount of protein while</p> <p>8 minimizing immunogenicity.</p> <p>9 And so the combination of different things</p> <p>10 you would put together to try to optimize a</p> <p>11 therapeutic is going to involve dampening</p> <p>12 immunogenicity. And that is teaching away from</p> <p>13 what you want as a vaccine.</p> <p>14 So if you're a POSA looking to develop a</p> <p>15 vaccine, you're going to look for platforms that</p> <p>16 are going to be driving immuno -- not just</p> <p>17 increased protein expression but protein</p> <p>18 expression of the antigen and immunogenicity.</p> <p>19 And sometimes the level of protein</p> <p>20 expression does not necessarily predict the level</p> <p>21 of immunogenicity. They're not necessarily hand</p> <p>22 in hand all the time. It depends on the nature of</p>	<p>267</p> <p>1 MS. MAYS-WILLIAMS: I object to the form</p> <p>2 of the question.</p> <p>3 Just slow down and give me time to object.</p> <p>4 Q. Are you aware that Dr. Griffin has no</p> <p>5 direct experience of such testing?</p> <p>6 MS. MAYS-WILLIAMS: I object to the form</p> <p>7 of the question.</p> <p>8 A. I am aware of that.</p> <p>9 Q. So as far as you know as between you and</p> <p>10 Dr. Griffin, you were the only one with direct</p> <p>11 firsthand experience answering that question of</p> <p>12 interchangeability?</p> <p>13 MS. MAYS-WILLIAMS: I object to the form</p> <p>14 of the question.</p> <p>15 A. So Dr. Griffin's experience</p> <p>16 was primarily -- when I looked through his</p> <p>17 references and his papers was primarily if it had</p> <p>18 anything to do with RNA, it was actually just</p> <p>19 characterizing the expression of mRNA in a cell.</p> <p>20 That is not vaccines. That is -- our</p> <p>21 bodies are full of RNA. RNA is being produced in</p> <p>22 all of our cells.</p>
<p>266</p> <p>1 the protein.</p> <p>2 Q. Okay. Shifting gears, you testified</p> <p>3 earlier this morning, in fact, about experiments</p> <p>4 that you've conducted comparing the</p> <p>5 interchangeability of different nucleic acid</p> <p>6 modalities. Do you remember that?</p> <p>7 A. Yes.</p> <p>8 MS. MAYS-WILLIAMS: I object to the form</p> <p>9 of the question.</p> <p>10 Q. One of those modalities was saRNA?</p> <p>11 A. Correct.</p> <p>12 Q. And you compared that to mRNA and DNA</p> <p>13 systems. Right?</p> <p>14 A. Right. These are ongoing experiments in</p> <p>15 my lab right now.</p> <p>16 Q. So you have direct firsthand experience</p> <p>17 testing whether one nucleic acid system is</p> <p>18 interchangeable or predictive of another. Right?</p> <p>19 A. That's right.</p> <p>20 Q. Now, you know Dr. Griffin. He's an expert</p> <p>21 for petitioners in this proceeding. Right?</p> <p>22 A. That's right.</p>	<p>268</p> <p>1 So he's just studying the amount of RNA</p> <p>2 being expressed in a cell that is triggered by a</p> <p>3 particular agonist.</p> <p>4 And so it's basic fundamental research to</p> <p>5 study, say, B cell immunology, but it's not mRNA</p> <p>6 vaccines, which is using mRNA to induce an immune</p> <p>7 response.</p> <p>8 So in my estimation, he had no experience</p> <p>9 in mRNA vaccines, no experience in nucleic acid</p> <p>10 vaccines of any sort.</p> <p>11 So my experience is, of course -- my</p> <p>12 entire career has been built on nucleic acid</p> <p>13 vaccines as a centerpoint of my research program.</p> <p>14 I was part of, one of half a dozen people</p> <p>15 back in the 1990s to start thinking about nucleic</p> <p>16 acid vaccines.</p> <p>17 And in 1992 I attended a conference to</p> <p>18 present what I thought was going to be the very</p> <p>19 first disclosure of a nucleic acid vaccine. And I</p> <p>20 was showing that we were able to take a DNA</p> <p>21 vaccine and induce an immune response in animals.</p> <p>22 And when I got there, there were six other</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

Conducted on August 2, 2024

<p style="text-align: right;">269</p> <p>1 people who were presenting on something similar 2 but with different methods of delivery and 3 different sorts of modalities. 4 So in 1992 at a Cold Spring Harbor 5 conference -- you can look it up if you want -- 6 that was the first time that nucleic acid vaccines 7 were known to everyone. It was an exciting 8 moment. 9 After the conference I do remember, 10 though, that everybody was excited about it, but 11 at the same time they were like, You don't think 12 this is actually ever going to work in people, do 13 you? 14 So that started my career in nucleic acid 15 vaccines. And I never stopped working on nucleic 16 acid vaccines since the early 1990s. 17 As I mentioned, throughout my career on 18 and off I would also investigate mRNA vaccines. 19 And then later, in 2019, I started to investigate 20 self-amplifying RNA vaccines as well. 21 And so today what I'm doing -- and I have 22 a graduate student whose thesis is actually</p>	<p style="text-align: right;">271</p> <p>1 different ways. 2 And that initial sensing drives a very 3 distinct, different pattern of innate immunity 4 which then leads to the type of adaptive immune 5 response you're going to get. 6 At the end of the day, it's no surprise to 7 me that each of these platforms would result in a 8 potentially entirely different immune response 9 even if you are using all of the same components. 10 For me, that's an exciting area of 11 research. Because now, if you think about it, we 12 could potentially leverage any one of these 13 platforms for whatever disease is out there, since 14 I always -- I teach a vaccines course to graduate 15 students. 16 I always say when you want to develop a 17 vaccine, you need to know what immunogen are you 18 going to use, you need to know what type of immune 19 response you're going to induce, you need to 20 identify a vaccine platform that's going to be 21 capable of inducing that immune response. 22 And depending on the disease, it's not the</p>
<p style="text-align: right;">270</p> <p>1 focused on this -- is trying to understand what 2 are the similarities and differences in terms of 3 DNA, mRNA, and self-amplifying RNA. 4 And what we are doing is using the same 5 immunogen we can plug into all three different 6 platforms. 7 And because we have different delivery 8 platforms that can work with all three, everything 9 is held constant except for the immunogen that we 10 insert. 11 And what we're finding is we insert the 12 same immunogen, let's say it's a spike protein 13 from coronavirus. And if we inject that into 14 mice, we see very different types of immune 15 responses induced by them both in terms of levels 16 of, say, neutralizing antibody, whether types of 17 T-cell responses induced and the like. 18 To me, this is really exciting. And it's 19 not surprising because if you think about how DNA 20 and RNA and self-amplifying RNA, when they go in a 21 cell they all have different sorts of molecular 22 properties. And cells sense them in very</p>	<p style="text-align: right;">272</p> <p>1 same. It's not always neutralizing antibody. 2 It's not always T-cell responses. Sometimes it's 3 going to be both. Sometimes it's going to be one 4 or the other. 5 So we have at our hands now really DNA, 6 mRNA, self-amplifying RNA. Very different types 7 of platforms that allow us the opportunity to 8 develop the best type of vaccine, the right 9 vaccine for the right type of disease that's out 10 there. 11 Q. So as the only expert in this proceeding 12 that has this direct firsthand experience -- 13 MS. MAYS-WILLIAMS: I object to the form 14 of the question. 15 Q. -- if you took an saRNA vaccine with a 16 particular protein choice and took that same 17 protein choice and made an mRNA vaccine, would you 18 expect the same results? 19 MS. MAYS-WILLIAMS: I object to the form 20 of the question. 21 A. No. 22 Q. And why not?</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 69 of 130

Conducted on August 2, 2024

<p style="text-align: right;">273</p> <p>1 A. Based on my experience and the data that I 2 have, I already know that when I compare 3 head-to-head an mRNA and a self-amplifying RNA 4 vaccine, not only do I get different magnitudes of 5 immune responses but I can actually characterize 6 very different types of immune responses as well 7 that are induced when we look at, for example, the 8 T-cell subset. 9 I'm not even going to get into mucosal 10 immunity because that's actually an entirely 11 different thing. I'm seeing something different 12 there as well. 13 So there's a whole different range of 14 immune responses and capabilities that are with 15 mRNA versus self-amplifying mRNA. 16 Q. Is the same true between DNA and mRNA? 17 Are those two nucleic acid modalities 18 interchangeable? 19 MS. MAYS-WILLIAMS: Objection. Objection 20 to the form. 21 A. They are not. They are not 22 interchangeable.</p>	<p style="text-align: right;">275</p> <p>1 difference. 2 And mRNA tends to be better at antibody 3 but less good at inducing those T-cell responses 4 and DNA tends to be better at T-cell responses, 5 rather than antibody. 6 I'm going to quantify one more variable 7 here because when I look at a particular 8 immunogen, I can see this difference. It's almost 9 a reciprocal difference between the two. 10 But if I swap that out and put in a 11 different immunogen, I can get an entirely 12 different outcome. 13 So every time you develop a vaccine, you 14 can't just assume that you can swap out an 15 entirely different immunogen from a different 16 pathogen and receive the exact same outcome with a 17 given platform. 18 MR. PRUSSIA: Give we one moment. I'll be 19 right back. Just a short break. 20 (Off the record, 4:47 p.m. to 4:51 p.m.) 21 MR. PRUSSIA: I have no further questions. 22 I pass.</p>
<p style="text-align: right;">274</p> <p>1 The way DNA and RNA is sensed inside the 2 cell, the beginnings of where we could see there 3 would be a substantial difference, one of the key 4 differences that I have presented at conferences 5 and I'm consistently finding, is that DNA 6 vaccines -- they were written off earlier on 7 because when they were brought to human clinical 8 trials, one of the primary endpoints for efficacy 9 was the ability to induce antibody. 10 And once you got into clinical trial, 11 although the DNA vaccines looked promising in 12 various animal models, for most clinical trials 13 with DNA vaccine, they failed to induce, in some 14 cases, in the majority of the people, even a 15 detectable antibody response. 16 What DNA vaccines are really good at is 17 induction of T-cell responses, including what we 18 call CD8-positive T-cells or CTL responses. 19 Now, mRNA vaccines can induce those types 20 of responses first as well, but when you look at 21 the relative ability of mRNA to induce those 22 responses compared to DNA, there's a huge</p>	<p style="text-align: right;">276</p> <p>1 MS. MAYS-WILLIAMS: We'll go off the 2 record briefly. 3 (Off the record, 4:51 p.m. to 4:53 p.m.) 4 MS. MAYS-WILLIAMS: We have no further 5 questions. Thank you, Dr. Fuller, and to the 6 court reporter as well. Very much appreciated. 7 THE WITNESS: Thank you very much. 8 (Off the record at 4:53 p.m.) 9 10 11 12 13 14 15 16 17 18 19 20 21 22</p>

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

BioNTech-Pfizer Exhibit 1104

BioNTech SE and Pfizer Inc. v. ModernaTX, Inc. IPR2023-01358

Page 70 of 130

Transcript of Deborah Fuller, Ph.D.
Conducted on August 2, 2024

70 (277 to 280)

277

CERTIFICATE OF SHORTHAND REPORTER - NOTARY PUBLIC

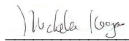
I, Michelle Keegan, Registered Merit
Reporter and Notary Public within and for the
Commonwealth of Massachusetts, do hereby certify:
That DEBORAH FULLER, PH.D., the witness
whose deposition is hereinbefore set forth, was
duly sworn by me before the commencement of such
deposition and that such deposition was taken
before me and is a true record of the testimony
given by such witness.

I further certify that the adverse party,
MODERNATX, INC., was represented by counsel at
the deposition.

I further certify that the deposition of
DEBORAH FULLER, PH.D. occurred at the offices
of Wilmer Cutler Pickering Hale and Dorr LLP,
60 State Street, Boston, Massachusetts 02109, on
Friday, August 2, 2024, commencing at 9:07 a.m. to
4:53 p.m.

I further certify that I am not related to
any of the parties to this action by blood or
marriage, I am not employed by or an attorney to
any of the parties in this action, and that I am
in no way interested, financially or otherwise, in
the outcome of this matter.

IN WITNESS WHEREOF, I have hereunto set my hand
this 3rd day of August, 2024.
My commission expires May 15, 2026.



NOTARY PUBLIC IN AND FOR THE

COMMONWEALTH OF MASSACHUSETTS

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM

A			
ability 8:11, 8:13, 19:11, 60:15, 97:21, 274:9, 274:21	184:7 ace2 58:6 achieve 188:8, 188:14, 256:14, 258:12 achieved 191:18 acid 24:2, 24:5, 24:7, 32:7, 32:11, 32:14, 40:5, 43:21, 44:5, 44:11, 44:19, 45:1, 48:12, 48:22, 49:3, 52:1, 53:9, 53:14, 53:15, 53:19, 54:2, 54:6, 54:21, 55:2, 56:14, 57:17, 74:6, 74:10, 74:18, 74:20, 77:1, 77:4, 84:11, 84:22, 105:19, 106:4, 127:13, 128:3, 153:6, 185:16, 185:21, 186:1, 186:5, 194:18, 194:22, 195:3, 196:6, 196:8, 208:3, 236:15, 266:5, 266:17, 268:9, 268:12, 268:16, 268:19, 269:6, 269:14, 269:16, 273:17 acids 34:9, 53:6, 77:4, 105:18, 106:2, 133:18, 134:2, 141:19, 213:2, 213:3 acknowledge 104:3 acquire 19:11	across 180:19 action 277:23, 277:25 actions 26:12 activated 63:5 activation 221:9, 221:16 activity 128:8, 145:17 actual 123:22, 174:19 actually 13:12, 15:16, 18:22, 25:21, 26:4, 27:19, 45:8, 46:1, 55:4, 73:3, 82:13, 84:3, 85:8, 88:17, 89:20, 94:1, 95:20, 97:11, 97:15, 101:16, 116:7, 117:18, 120:10, 120:15, 122:12, 124:3, 127:1, 127:15, 128:15, 128:20, 131:11, 135:1, 136:1, 137:12, 140:16, 155:9, 166:17, 168:14, 170:11, 174:15, 193:5, 193:13, 199:6, 203:14, 211:8, 213:11, 239:2, 240:4, 245:3, 246:3, 254:5, 259:15, 260:11, 267:18, 269:12, 269:22, 273:5, 273:10 acute 57:1, 125:19 adaptive 271:4	add 252:16, 262:1 added 123:12, 174:22, 207:10, 208:6 additional 77:10, 81:7, 83:17, 101:2, 104:10, 120:14, 123:11, 123:12, 135:21, 155:7, 173:18, 260:17 address 7:14 addressed 243:16, 251:9 addressing 100:6, 253:18 adequate 20:22, 21:6, 22:7, 220:13 adjuvant 99:4 administered 78:18, 119:17, 119:21, 237:12, 261:20 administering 144:21, 153:5 administrating 145:4 administration 38:18, 39:1, 130:22, 240:15 administrative 9:7 adopted 183:11, 184:20 adults 178:13 advance 262:22 advanced 185:11, 185:14 advances 200:18 advantage 104:15, 105:7

advantages 82:22, 83:3, 83:5, 188:21, 189:1 adverse 277:12 advisory 13:17, 13:20 affecting 8:13 afford 257:1 after 32:22, 33:15, 37:3, 53:2, 60:20, 76:6, 79:13, 101:2, 127:22, 149:13, 202:22, 238:15, 240:15, 246:20, 249:22, 269:9 afternoon 263:8 again 24:18, 30:16, 31:2, 38:22, 39:5, 53:11, 64:8, 70:16, 92:3, 92:11, 95:11, 101:10, 107:9, 109:3, 111:5, 117:16, 121:11, 125:8, 133:5, 141:3, 143:2, 151:4, 151:14, 157:4, 159:2, 165:7, 177:17, 187:20, 192:21, 197:22, 202:10, 202:11, 203:16, 207:1, 209:19, 210:7, 214:17, 215:1, 221:1, 221:13, 225:8, 231:1, 260:16, 265:2 against 20:3, 20:19,	20:21, 21:10, 21:15, 22:19, 23:1, 23:2, 23:5, 23:13, 40:17, 40:21, 41:5, 41:17, 42:2, 59:11, 59:12, 60:3, 60:5, 60:12, 60:14, 60:18, 61:5, 61:8, 61:14, 61:18, 62:3, 62:12, 62:19, 63:22, 64:6, 64:14, 66:3, 67:9, 68:8, 72:14, 73:10, 73:20, 90:9, 97:2, 97:12, 97:16, 100:8, 118:19, 119:8, 132:9, 145:17, 197:5, 234:21, 235:4, 240:18, 260:20 agarose 112:19 agent 34:8, 113:21 ago 23:20, 26:21, 53:3, 55:19, 63:22, 64:5, 79:14, 80:3, 81:20, 82:3, 85:7, 201:9, 203:2, 203:22 agonist 268:3 agree 103:9, 126:5, 128:11, 158:14, 184:8, 184:10, 184:16, 189:4, 191:4, 191:17, 192:3, 220:17, 236:9, 239:14, 239:17, 243:3	agreement 209:4 agrees 189:20 ahead 64:4, 91:5, 140:22, 142:8, 175:6, 177:9, 192:1, 211:7, 228:4, 229:22 all 24:6, 25:7, 28:6, 28:22, 43:14, 45:13, 47:1, 48:6, 48:8, 70:18, 73:1, 78:21, 84:16, 85:19, 85:21, 91:17, 99:6, 99:22, 114:8, 114:11, 117:17, 129:12, 140:11, 147:18, 148:1, 148:7, 148:14, 150:2, 153:4, 166:18, 168:18, 171:9, 171:19, 174:8, 174:19, 175:20, 176:11, 176:13, 185:2, 192:14, 201:1, 208:11, 220:11, 220:15, 229:4, 233:8, 240:20, 241:7, 243:7, 251:3, 251:6, 251:9, 253:14, 253:17, 253:21, 265:22, 267:22, 270:5, 270:8, 270:21, 271:9 alleged 209:9 allergen 241:5 allow 263:10, 272:7	allowing 191:19, 193:9, 193:17 allows 192:16, 192:22, 228:10 almost 245:11, 275:8 alone 149:19, 258:22 along 80:21, 265:1 alphavirus-deriv- ed 5:11, 35:7, 37:9, 67:19 already 29:9, 50:13, 52:15, 67:17, 67:18, 68:1, 82:18, 88:15, 129:2, 152:11, 208:20, 230:22, 233:15, 249:6, 273:2 also 4:11, 7:22, 10:6, 13:2, 16:1, 37:14, 37:19, 44:21, 52:10, 99:2, 99:5, 104:7, 106:4, 114:6, 114:16, 116:6, 122:14, 150:13, 175:22, 184:21, 207:7, 207:15, 229:15, 251:5, 269:18 although 126:11, 128:16, 131:18, 274:11 altmeyer 244:7 alveolus 58:8 always 104:2, 106:9,
--	---	---	--

120:21, 144:1, 149:10, 152:19, 242:13, 271:14, 271:16, 272:1, 272:2 amino 133:17, 134:2 among 34:14, 141:19, 147:18, 195:6, 241:9, 251:3 amount 63:7, 153:10, 154:2, 154:3, 219:1, 227:2, 228:18, 236:17, 237:8, 255:6, 265:6, 265:7, 268:1 amounts 97:17, 100:18, 237:21 amplifies 188:17 analysis 159:3, 251:9 analyzed 33:15 anastasia 14:7, 14:9 and-forth 165:12 angiotensin-conv- erting 58:6 animal 29:15, 39:10, 46:11, 47:21, 52:5, 52:8, 54:19, 63:9, 145:13, 197:2, 253:17, 257:2, 257:10, 274:12 animals 256:9, 268:21 ankara 28:19 annotations 8:21	another 28:21, 29:3, 29:4, 47:11, 50:15, 55:12, 84:10, 101:8, 148:1, 157:8, 161:6, 164:18, 177:10, 227:6, 227:11, 235:19, 236:6, 236:14, 266:18 answer 8:10, 9:10, 9:13, 9:19, 10:14, 67:11, 84:12, 85:5, 151:2, 152:9, 155:3, 173:8, 173:19, 177:8, 190:19, 191:22, 217:2, 220:6, 221:11, 233:10, 233:14, 233:15, 234:10, 234:11, 234:13, 264:7 answered 155:2, 173:3, 212:22, 220:22, 221:5, 222:9, 231:4, 231:8, 231:9, 233:8, 233:11, 238:12, 249:5 answering 177:2, 221:14, 233:8, 267:11 answers 10:3, 263:22 anti-s 72:15, 73:11, 73:22 antibodies 30:8, 42:2, 52:11, 59:10, 60:3, 60:11, 61:8, 61:18, 72:13, 72:16, 73:4, 73:8,	73:11, 73:14, 73:22, 118:8, 118:22, 128:7, 144:17, 196:20, 197:12, 256:7, 260:2, 260:4, 260:17, 260:18, 260:20, 261:4, 261:7 antibody 5:14, 30:3, 30:5, 35:9, 40:16, 40:20, 41:5, 41:17, 42:1, 44:22, 49:12, 49:21, 50:6, 51:10, 59:16, 60:8, 60:13, 61:21, 62:3, 68:11, 73:2, 73:4, 119:6, 144:11, 144:14, 144:17, 144:20, 145:1, 145:6, 147:17, 147:19, 148:8, 148:20, 149:13, 149:14, 149:15, 150:8, 150:11, 150:15, 150:18, 151:7, 152:2, 152:6, 152:8, 152:18, 152:20, 155:9, 155:11, 155:15, 155:17, 155:20, 156:2, 156:4, 187:8, 217:7, 217:8, 241:1, 257:8, 258:19, 259:4, 260:11, 260:15, 270:16, 272:1, 274:9, 274:15, 275:2, 275:5 anticipate 213:21, 214:6, 215:14, 216:18, 219:6, 220:16,	235:13 anticipated 46:6 anticipates 209:14, 209:21, 210:9, 214:13, 214:19, 215:3, 215:19, 216:6, 216:12, 216:14 anticipating 182:2, 182:11, 220:12 anticipation 181:8, 181:12, 181:14, 181:20, 209:10, 211:11, 211:13, 213:16, 214:15, 214:21, 215:5, 215:7, 216:11, 217:17, 220:3, 220:12 anticipatory 215:9, 217:21, 218:8, 218:13, 218:18, 218:20, 219:21, 222:4 antigen 27:15, 27:21, 28:7, 29:2, 29:5, 29:10, 29:19, 30:13, 31:16, 31:20, 39:17, 40:11, 43:1, 43:9, 45:6, 52:7, 52:12, 118:9, 141:12, 186:22, 187:5, 187:19, 188:3, 188:9, 188:15, 235:15, 235:17, 248:7, 265:18 antigen's 74:12 antigens 25:16, 25:19, 26:3, 26:8, 26:22, 27:13,
---	---	---	---

28:2, 31:9, 39:20, 66:1, 118:6, 249:20 antivirals 23:11 any 8:20, 10:11, 18:20, 23:1, 31:14, 31:22, 34:11, 34:13, 34:16, 34:19, 34:21, 40:8, 50:2, 50:11, 53:21, 55:14, 55:17, 64:13, 64:20, 65:15, 66:3, 66:5, 67:8, 68:19, 76:11, 78:5, 88:6, 88:22, 93:10, 97:12, 115:12, 118:12, 119:7, 124:5, 125:2, 125:4, 128:6, 130:4, 131:2, 133:15, 135:12, 140:15, 141:14, 141:16, 141:19, 142:14, 146:20, 153:21, 154:8, 154:22, 155:6, 156:3, 156:20, 162:10, 164:22, 165:16, 167:11, 167:15, 169:9, 170:11, 170:18, 172:12, 173:11, 176:10, 176:15, 178:3, 189:21, 212:15, 212:16, 213:6, 216:5, 216:6, 216:10, 216:14, 217:19, 219:2, 219:3, 219:4, 220:8, 221:22, 227:14, 234:9, 235:22, 236:4,	248:22, 256:18, 262:14, 263:15, 264:5, 268:10, 271:12, 277:23, 277:25 anymore 127:10 anyone 14:12 anything 8:13, 15:2, 15:13, 15:18, 16:18, 66:20, 98:15, 98:18, 106:5, 106:7, 108:13, 213:19, 216:12, 222:17, 233:2, 233:18, 263:2, 267:18 anytime 208:8 anywhere 180:16, 212:17 apologies 24:19, 70:17 apologize 103:8, 104:20, 127:17 appeal 1:3, 10:19 appealing 262:7 appearances 4:1 appendices 159:7 appendix 176:4, 176:7, 176:8, 250:8 applicability 264:17 applicable 204:2 application 26:1, 84:11, 84:20, 122:19, 123:9, 130:2, 160:2, 160:16,	160:17, 161:9, 172:14, 173:9, 212:17, 235:18, 235:19, 236:1, 236:5, 256:6 applications 94:7, 96:11, 160:22 applied 130:1, 181:5, 181:9, 181:20, 201:11 apply 27:16, 48:11, 48:20 applying 211:11 appreciated 276:6 approach 85:5, 94:19, 228:7 approaches 5:21, 43:22, 44:3, 142:22, 143:6, 143:9, 143:15, 257:17 appropriate 104:2 approve 168:16 approved 20:18, 100:21, 167:5, 167:6, 167:21, 168:3, 168:7, 168:20, 169:4, 170:3 approximate 82:8 approximately 9:15, 174:1, 174:13, 201:1 area 108:7, 157:1, 161:10, 233:10, 271:10 areas 184:16	argued 243:11, 243:18 around 56:5, 58:3, 60:21, 63:1, 63:2, 79:21, 175:1, 175:7, 196:7, 203:20 arrive 122:2, 204:5, 244:19 art 130:21, 168:16, 181:16, 183:8, 209:15, 209:17, 209:21, 210:2, 210:11, 210:16, 211:15, 211:19, 214:5, 214:13, 214:19, 215:3, 217:20, 243:13, 257:5, 262:7, 262:10, 263:10 articles 76:4, 77:9, 99:22, 104:4, 104:10, 107:19, 194:7 ashley 3:5 aside 64:15, 124:15, 124:19 asked 9:11, 13:19, 67:8, 82:12, 141:1, 155:1, 157:1, 157:4, 173:2, 173:5, 212:21, 220:21, 221:4, 222:8, 231:3, 231:8, 238:11, 249:4, 254:16, 255:1, 257:12, 257:19, 263:8, 263:14 asking 27:10, 64:19,
--	--	---	--

87:9, 87:15, 125:14, 155:14, 155:16, 155:20, 155:22, 169:20, 225:13 aspect 44:20, 162:10, 223:8 aspects 93:20, 162:12 assays 228:9, 232:5 assess 252:6 associated 14:3, 27:7, 96:2, 152:12, 198:20, 200:12, 227:13, 229:10, 229:12, 249:9, 251:11, 252:7, 252:9, 252:11, 252:19, 260:2 assume 10:14, 275:14 assumed 246:16 assuming 134:21 attach 60:15 attached 5:8, 6:2, 18:3, 35:2, 70:3, 75:8, 88:14, 102:11, 122:16, 142:2, 198:9, 209:2, 239:5 attachment 71:15 attended 268:17 attention 107:22, 126:17, 247:7 attorney 14:16, 124:7, 218:4, 277:24	attorneys 14:4, 17:2, 159:19, 175:20, 177:22, 178:18 attractive 246:5 august 1:21, 36:21, 37:2, 37:3, 277:20, 277:30 author 35:12, 35:16, 35:22, 36:3, 75:19, 89:12, 89:15, 142:6, 160:9, 238:22 author's 101:3 authors 16:14, 142:14, 142:17 autoimmune 5:18, 75:14 automatically 120:21 avenue 3:8, 3:16 average 163:14 avoid 152:16 aware 12:21, 64:13, 64:20, 65:15, 65:19, 69:20, 119:10, 141:14, 183:11, 215:18, 226:9, 235:18, 235:21, 243:10, 251:16, 252:1, 252:3, 267:4, 267:8 away 61:3, 98:18, 126:16, 245:4, 265:12 <hr/> B <hr/> back 23:8, 30:18,	49:8, 49:17, 52:14, 56:21, 68:3, 72:8, 74:5, 82:10, 99:1, 101:7, 111:8, 113:10, 134:16, 144:2, 145:14, 153:1, 165:11, 165:12, 170:10, 203:17, 204:7, 208:13, 213:14, 217:16, 235:10, 240:4, 257:11, 268:15, 275:19 background 130:19, 158:4, 165:19, 166:14, 168:19, 219:13 backwards 53:12 bacterial 241:4 bacterium 240:18 bad 260:18 bainbridge 7:15 balls 105:17 barda 84:11 barney 142:16, 142:17, 261:17, 262:1 barrier 83:17 based 27:6, 29:6, 42:20, 50:7, 75:18, 77:5, 87:11, 98:12, 101:10, 145:15, 150:19, 151:6, 158:18, 244:21, 246:9, 261:15, 262:15, 273:1	basic 51:22, 165:21, 166:14, 268:4 basically 41:20, 84:21, 125:12, 223:15, 228:13, 228:20, 230:3, 264:7 basis 51:15, 238:7 bearings 149:20 became 81:7 because 10:1, 22:7, 25:11, 31:6, 38:6, 41:10, 42:17, 45:10, 56:12, 59:11, 60:4, 61:1, 63:8, 63:12, 69:17, 71:13, 83:16, 84:16, 90:20, 94:8, 96:22, 97:19, 98:19, 99:6, 117:12, 121:13, 124:8, 125:22, 126:12, 126:20, 127:2, 127:10, 131:20, 133:17, 135:21, 136:20, 137:10, 139:9, 144:17, 146:21, 148:11, 148:16, 149:22, 150:3, 152:10, 158:18, 160:17, 169:17, 171:19, 177:20, 178:15, 178:17, 189:12, 196:7, 207:18, 213:14, 218:18, 229:3, 229:9, 234:18, 235:14, 246:13, 252:2, 253:21, 259:17, 259:19,
---	--	---	--

260:13, 260:17, 261:3, 262:4, 264:21, 270:7, 270:19, 271:11, 273:10, 274:7, 275:7 become 80:12, 143:21, 146:15, 200:3, 201:22 beehives 126:14 been 7:3, 8:3, 11:21, 12:10, 12:13, 13:4, 13:15, 17:18, 18:5, 21:17, 21:19, 27:6, 32:11, 35:4, 36:7, 36:10, 39:9, 46:9, 46:13, 46:19, 58:16, 58:18, 58:19, 59:20, 60:20, 60:21, 63:1, 69:21, 73:14, 73:16, 73:18, 75:3, 76:9, 76:15, 76:19, 85:3, 88:15, 99:9, 101:1, 102:7, 106:20, 107:6, 107:12, 112:18, 122:13, 122:14, 123:8, 124:8, 126:9, 142:5, 145:12, 150:5, 165:9, 169:1, 170:19, 179:6, 182:10, 191:9, 193:21, 194:18, 196:2, 196:8, 196:14, 200:10, 201:8, 203:22, 204:3, 206:10, 208:20, 211:12,	214:9, 239:6, 243:19, 244:13, 246:8, 246:12, 246:14, 252:9, 268:12 before 1:3, 2:12, 8:3, 9:6, 9:19, 10:18, 12:22, 18:6, 36:1, 54:18, 56:17, 57:15, 58:18, 58:19, 59:7, 83:8, 85:4, 90:21, 91:21, 96:16, 99:11, 100:21, 103:1, 125:9, 125:10, 125:21, 130:14, 142:10, 142:11, 142:12, 145:13, 156:12, 170:17, 196:13, 197:22, 198:3, 199:6, 203:17, 221:12, 230:2, 233:11, 235:5, 247:3, 253:11, 277:7, 277:9 began 12:22, 23:20, 37:4, 49:9, 49:17, 80:13, 174:13 begin 13:13, 23:19, 39:12, 174:10 beginning 8:7, 129:4, 222:19 beginnings 274:2 begins 118:1 begun 45:16 behalf 3:3, 3:12, 4:3,	11:15 behind 74:21 being 9:1, 9:3, 25:1, 48:18, 48:21, 87:17, 96:20, 100:14, 116:2, 125:21, 146:6, 194:5, 201:11, 204:2, 213:11, 225:9, 227:2, 243:16, 244:10, 249:9, 251:2, 256:11, 257:19, 263:7, 267:21, 268:2 beiser 127:5 believe 16:17, 37:8, 55:15, 150:12, 158:9, 164:7, 182:8, 185:19, 195:8, 204:11, 205:10, 244:9 believed 80:8 below 140:14 benefit 264:1, 264:5, 264:12 besides 21:12, 63:12, 63:15, 217:15 best 8:11, 10:8, 27:12, 29:15, 36:4, 36:17, 272:8 betacoronavirus 21:19, 22:11, 126:6, 132:10, 132:12, 138:11, 138:16, 153:8, 235:14, 235:16, 239:16, 242:1,	246:8, 249:20, 250:10, 250:12, 250:14, 255:20, 261:11, 262:13, 264:18 betacoronaviruses 21:11, 21:12, 21:16, 131:16, 251:14 betacov 153:8, 153:11, 255:7 better 30:5, 152:19, 164:2, 275:2, 275:4 between 19:13, 32:18, 33:4, 112:2, 123:21, 124:14, 162:3, 180:22, 187:18, 188:2, 200:9, 202:20, 242:9, 267:9, 273:16, 275:9 beyond 60:22, 108:13, 180:8, 195:17 bias 252:7 big 66:12, 115:15, 115:17, 140:9 big-picture 115:17 bigger 100:7, 152:7 bilayer 115:22 binding 58:5, 58:11, 59:14, 60:7, 62:13, 62:20, 68:10, 144:9 bioavailability 90:11 biological 89:9, 91:3,
--	---	--	---

91:13, 95:14, 95:18 biology 52:1, 146:5 biontech 1:5, 3:4, 4:12, 7:7, 182:11, 209:9, 243:10, 243:18, 244:5 biotech 47:8, 54:15, 56:12 bit 29:17, 33:17, 50:20, 51:16, 62:22, 75:4, 81:6, 110:20, 123:18, 158:6, 162:13, 163:1, 170:21, 182:20, 229:18, 233:16, 237:2 bits 244:1 blanking 205:1 block 121:5, 260:1 blocks 201:13 blood 227:1, 227:3, 277:23 board 1:3, 10:19, 13:17, 13:18, 13:20, 183:11, 184:20 board's 183:15, 183:18, 184:2, 184:5, 185:18 bodies 267:21 body 38:20, 39:3, 83:7, 83:16, 88:5, 90:21,	93:11, 93:12, 94:15, 95:16, 95:19, 96:20, 97:1, 100:17, 116:3, 116:4, 128:19, 146:14, 146:16, 147:3, 194:17, 195:5, 261:15, 262:18 body's 128:5, 130:3, 131:1 boost 149:8, 149:9, 149:16, 149:17, 151:19, 258:14, 258:18, 259:4 boosted 147:16, 148:7, 148:13 booster 196:4, 259:1, 261:5 boston 1:20, 2:6, 4:8, 277:19 both 11:19, 12:5, 20:9, 24:2, 24:5, 25:3, 31:6, 31:18, 32:19, 77:12, 78:2, 81:17, 95:1, 96:3, 96:15, 98:8, 103:10, 105:18, 122:12, 141:7, 146:18, 158:9, 158:11, 158:14, 162:3, 165:2, 176:4, 195:11, 205:4, 205:8, 209:5, 256:3, 270:15, 272:3 bottom 23:9, 56:22, 117:21, 118:1, 199:7, 199:9,	199:17, 204:14, 204:15, 240:1, 240:8, 241:12 break 9:15, 9:16, 9:19, 75:4, 157:8, 158:5, 208:15, 218:3, 246:22, 247:3, 254:7, 254:8, 275:19 briefly 276:2 bring 98:22, 161:13, 161:14, 201:17 bringing 54:18, 203:15 broad 27:13, 81:12 broader 44:20 broadly 81:21 brought 8:16, 125:21, 141:4, 178:19, 203:19, 261:1, 261:10, 274:7 bubble 116:1 build 127:14, 128:3, 201:13 building 201:13 built 119:10, 129:1, 129:5, 268:12 burden 210:15, 211:18 business 17:9, 17:10, 17:11 <hr/> C <hr/> calendar 180:3	call 13:21, 26:12, 28:14, 31:22, 112:3, 242:22, 243:2, 274:18 called 67:21 calls 218:1, 219:8, 228:2 came 14:13, 17:5, 19:2, 68:2, 74:19, 84:1, 176:13, 186:11, 206:5 can't 15:19, 43:6, 50:11, 56:11, 89:4, 120:20, 121:14, 135:5, 135:9, 137:9, 142:12, 172:22, 174:2, 178:17, 180:8, 183:3, 206:15, 275:14 cancer 81:3, 81:7, 100:9 cancers 5:18, 75:14, 81:5, 81:13 candidate 5:21, 37:10, 38:8, 39:13, 39:18, 39:21, 40:12, 43:1, 44:7, 44:14, 45:3, 45:19, 48:4, 49:11, 49:20, 51:1, 51:9, 62:6, 64:15, 66:10, 66:17, 67:6, 67:15, 132:19, 143:8, 240:12, 255:21, 257:16 candidates 62:15, 66:22,
---	--	--	--

67:10, 251:19 cap 134:13, 134:14, 134:15, 134:18, 134:20, 135:1, 205:18, 206:1 capabilities 273:14 capability 80:14 capable 271:21 capacity 89:9, 94:20 caps 206:7, 206:16, 207:2 cared 127:10 career 127:7, 268:12, 269:14, 269:17 carrier 47:7, 48:19, 191:19 carry 189:6 case 1:11, 1:14, 52:5, 54:3, 67:21, 77:16, 77:21, 99:3, 131:7, 158:21, 159:2, 232:8, 232:13, 238:16, 245:4 cases 12:5, 206:11, 206:12, 274:14 cassette 48:8, 208:8 cassettes 25:4, 47:1 categories 156:16 cationic 109:7, 109:13, 109:17, 109:22,	110:5, 110:12, 110:14, 110:21, 111:1, 112:1, 112:4, 112:5, 117:5, 136:5, 136:7, 137:14, 139:14, 139:16, 139:19, 140:9, 153:13, 156:16, 156:21, 225:17, 226:1, 226:5 cause 142:21, 143:5 caused 57:5 causes 118:16 cautious 246:12 cd8-positive 274:18 cell 5:14, 38:15, 52:5, 52:6, 58:7, 77:18, 83:7, 83:12, 105:21, 115:19, 116:9, 188:5, 267:19, 268:2, 268:5, 270:21, 274:2 cell's 116:7 cell-mediated 241:2 cells 34:10, 39:9, 58:8, 60:16, 78:8, 78:19, 86:10, 102:1, 103:12, 128:9, 202:7, 203:6, 213:3, 267:22, 270:22 cellular 128:5, 130:3, 131:1, 187:18, 188:2, 188:8,	188:14, 189:22 center 8:2, 19:1 centered 63:1 centerpoint 268:13 central 146:5, 146:9, 214:10 century 186:11 certain 53:7, 67:4, 138:18, 188:21, 215:14, 249:10 certainly 100:14, 150:10, 171:9, 171:10, 172:2, 172:3, 194:19 certainty 178:3 certificate 277:1 certify 277:4, 277:12, 277:16, 277:22 challenge 197:14, 250:1 challenged 72:13, 73:8, 73:18, 209:10, 210:16, 211:19 challenger's 210:15, 211:18 chan 108:11, 109:3 change 50:20, 53:17 changed 233:16 changes 101:2, 170:15 changing 48:9 characterization 111:10, 111:15	characterize 195:2, 273:5 characterizing 73:4, 267:19 check 64:22, 113:7, 137:5, 220:5 checked 85:21 checks 78:21 chemical 141:4, 194:3 chemist 108:10, 137:10 chemistry 108:5, 115:15 children 118:17 china 125:20 choice 248:7, 272:16, 272:17 choices 67:14 cholesterol 112:9, 112:11, 117:7, 136:11, 138:3, 140:6, 153:14, 156:17, 225:7, 225:18, 226:2, 226:6 choose 27:2, 28:1, 29:5, 40:10, 45:5, 245:12 choosing 42:22 chose 29:9, 39:16, 63:17, 63:19 chronically 178:11 circulating 15:12, 20:4, 20:8, 20:11, 22:17, 31:12,
--	---	---	--

<p>227:3 citations 36:17, 73:12 cite 72:2, 99:14, 104:9, 249:18 cited 14:22, 15:2, 15:16, 36:8, 36:13, 36:19, 65:1, 68:14, 69:16, 85:14, 91:1, 91:12, 91:19, 92:4, 92:14, 93:1, 99:22, 100:14, 104:10, 107:18, 194:6, 198:1, 199:7 citing 72:19, 72:21, 198:4 claim 153:4, 153:22, 154:10, 154:13, 154:21, 155:13, 155:19, 156:1, 156:14, 170:19, 171:5, 181:13, 181:15, 209:14, 209:21, 210:9, 210:10, 210:16, 211:12, 211:14, 211:19, 213:22, 214:6, 214:14, 214:20, 215:4, 244:20, 254:17, 257:3, 257:5 claims 124:2, 124:15, 124:19, 125:7, 125:9, 125:10, 131:18, 153:1, 153:3, 155:18, 209:10, 215:14, 216:6, 216:14, 219:7, 235:13, 243:11, 243:18,</p>	<p>255:2 claire 4:5, 12:19, 12:20, 14:7, 14:9, 17:21, 17:22 clarifications 155:8 clarify 81:11, 81:19, 96:7, 99:3, 107:9, 124:11, 162:16, 165:6, 174:18, 177:14, 230:2 class 195:3 classified 24:6 clear 72:5, 82:16, 96:1, 99:17, 117:17, 138:17, 138:19, 138:21, 219:12, 253:3, 261:10, 263:21 clinic 261:11 clinical 79:9, 94:8, 118:18, 196:9, 274:7, 274:10, 274:12 close 234:12 closer 160:17 coadministration 99:4 code 78:7, 78:14 coding 38:18, 86:10, 134:7, 203:7, 205:1, 228:15 coinvestigator 161:7 cold 269:4</p>	<p>collaborate 160:1 collaborated 56:13, 159:19 collaborating 54:16, 161:4, 169:8 collaboration 47:7, 47:11, 159:21, 161:12, 162:3, 162:9, 163:12, 165:13 collaborators 170:20 colleague 127:5 column 112:17, 118:1, 125:18, 127:11, 127:18, 127:19, 129:21, 131:22, 136:2, 137:22, 138:8, 138:21, 139:15, 199:5, 199:8, 199:9, 199:10, 199:11, 199:12 columns 131:22 combination 193:21, 244:4, 244:12, 265:9 combinations 243:20 combine 244:3, 244:18, 245:11, 245:16, 245:18, 258:13, 258:17, 259:10 combined 201:15, 244:10, 261:5 combining 245:21, 262:5 come 13:11, 32:12, 201:2, 220:15, 245:13</p>	<p>comes 18:7, 148:11, 238:15 comfortable 233:7 coming 129:17 commencement 277:7 commencing 277:20 comment 137:9 comments 76:11 commission 277:31 common 62:1, 149:17, 197:2 commonly 106:3 commonwealth 2:14, 277:4, 277:35 company 47:8, 54:15, 56:13 compare 25:7, 84:14, 151:15, 273:2 compared 33:6, 33:9, 55:12, 188:21, 256:9, 266:12, 274:22 comparing 84:7, 149:7, 151:14, 172:16, 173:10, 189:9, 266:4 comparison 55:5, 258:22, 259:12, 260:19 compel 246:2 compelling 97:14, 196:16</p>
---	--	---	---

compensated 9:1, 9:3 complete 98:11, 162:2 completely 20:14, 50:17, 91:17, 98:1 completion 142:11 component 30:7, 30:11, 38:16, 137:14 components 48:6, 108:3, 108:7, 108:8, 164:12, 200:21, 271:9 composition 147:1, 153:19, 245:13 compositions 108:12 comprise 224:4, 224:17, 240:22 comprises 153:13 comprising 132:20, 153:5, 153:7, 156:15, 224:3, 224:10, 224:15 computer 165:15, 166:15, 166:20, 167:10, 170:10 concept 111:17, 130:8, 130:10, 197:3 conception 74:19 conceptualization 96:16, 128:17 concern 63:7, 63:13, 125:22, 144:1, 251:3, 260:16 concerned 253:22, 259:18	concerns 190:18, 195:13, 198:20, 200:12, 205:5, 205:8 conclude 233:2, 233:18 concluded 33:17 conclusion 202:21, 218:2, 219:9, 228:3 conclusions 262:9, 262:15, 263:11, 264:17 conclusively 120:20 conditions 54:17, 139:12, 228:8 conducted 266:4 conference 268:17, 269:5, 269:9 conferences 142:12, 274:4 conferred 94:22, 98:7 confidence 46:1, 253:11, 254:1 confidentiality 56:12 confirm 89:3 confused 264:6 connect 149:22 connection 158:8 connolly 3:15 conserved 23:12, 26:16, 30:13, 118:8, 118:21, 119:1, 119:4	consider 67:13, 83:20, 184:5 considerable 94:6, 96:10, 129:18, 242:11 considered 69:17, 176:3, 176:16 consistent 160:11, 172:7, 202:2, 203:10, 259:8 consistently 32:20, 33:4, 249:8, 274:5 constant 28:7, 270:9 constantly 15:22 constitutes 219:14, 219:20 construct 144:22 constructs 128:8 consult 121:8 consultancy 13:8, 13:13 consultant 13:12 consulted 54:6, 54:8 consulting 12:22, 13:2, 13:4 contact 17:16 contacted 12:7, 12:9, 12:14 contain 8:20 contains 134:8, 159:2 contemporary 15:7, 15:9,	16:19, 201:16 content 162:13, 162:18, 163:4, 163:8, 163:20, 164:1, 164:3, 164:8, 164:10, 164:14, 165:11, 166:9, 166:20, 167:17, 167:19, 168:21, 169:12, 170:2 contents 166:6, 166:8, 166:22, 168:11, 169:16 context 38:15, 59:1, 67:1, 95:12, 99:12, 99:13, 107:15, 110:19, 113:5, 115:10, 139:4, 152:20, 206:19, 207:3, 228:6, 233:1, 233:17, 235:1, 240:5, 248:22, 250:17, 252:5 continued 4:1, 261:2 continues 200:1, 205:18, 240:21 contribute 161:16, 164:15, 165:18, 169:11, 260:18 contributed 162:18, 163:8, 164:8, 164:17, 165:20, 166:1, 166:10, 167:17, 167:18, 168:21, 169:2, 170:2 control 27:8, 125:22, 256:9 controlled 126:9
---	---	--	--

conversation 9:8, 10:1, 75:18, 202:13, 202:17 coral 7:15 core 187:3 corner 204:15 coronavirus 15:11, 19:16, 19:21, 20:2, 20:10, 20:19, 21:1, 21:8, 21:9, 42:11, 42:15, 57:5, 126:2, 126:11, 127:4, 142:20, 143:4, 143:15, 240:2, 241:13, 241:17, 241:19, 242:1, 250:11, 270:13 coronavirus-2 57:3 coronaviruses 21:11, 42:17, 58:5, 58:11, 127:9, 251:13, 261:16 correction 69:13 correlate 257:9 correspond 27:7 corresponded 62:4 corresponding 35:16, 35:22, 36:3, 241:4 couldn't 131:19, 170:18 counsel 7:6, 9:12, 12:7, 85:7, 176:9, 176:17,	178:4, 179:13, 180:11, 183:7, 219:19, 229:20, 254:10, 254:22, 257:14, 257:21, 263:15, 263:22, 264:15, 277:13 counsel's 92:12 countries 125:21 couple 68:15 course 36:14, 37:3, 145:11, 180:19, 200:22, 256:10, 256:18, 258:7, 258:9, 268:11, 271:14 court 7:15, 9:22, 10:6, 18:4, 35:3, 75:11, 142:4, 276:6 cov 132:5, 141:18, 142:22, 143:7 cover 12:5, 184:15 covers 154:21 covid 22:20, 30:22, 31:8, 37:4, 57:5, 251:2, 253:3, 253:14 cowriting 161:5, 163:12 create 208:8 credited 89:21, 93:5, 93:6 critical 205:4, 205:8 cross-protection 26:19	crr 1:26 csr 1:26 ctl 274:18 current 7:20, 7:21, 19:7, 19:15, 19:20, 20:3, 20:7, 20:9, 20:11, 20:21, 21:6, 21:9, 22:5, 22:10, 22:12 currently 7:17, 7:18, 15:11, 20:18, 156:21 curriculum 5:10 curve 120:10 cutler 2:4, 4:6, 277:18 cutting-edge 196:1 cyto 192:18 cytoplasm 116:8, 191:20, 192:17, 192:19, 192:20, 193:1, 193:6, 193:7, 193:9, 193:15	43:21, 44:21, 48:3, 50:8, 54:8, 54:12, 54:16, 55:6, 61:20, 62:22, 84:7, 97:15, 98:14, 99:7, 124:22, 142:11, 149:1, 151:12, 212:16, 213:8, 213:14, 213:15, 213:17, 213:20, 214:5, 214:10, 214:14, 214:20, 215:4, 215:6, 217:18, 217:22, 218:9, 219:16, 245:8, 256:15, 262:16, 263:7, 263:16, 264:1, 264:6, 264:13, 264:15, 264:16, 273:1 date 13:9, 58:17, 76:3, 106:16, 106:21, 123:2, 123:5, 123:13, 158:19, 174:12, 190:10, 196:8, 200:10 dates 104:12 david 3:13, 127:5 day 17:9, 17:10, 17:11, 170:16, 171:11, 172:4, 172:15, 189:18, 262:8, 271:6, 277:30 dc 3:17 death 249:22 deborah 1:19, 2:1, 5:3,
--	--	--	---

5:10, 7:2, 7:13, 11:19, 277:5, 277:17 decade 200:2, 200:17, 201:1, 201:21 decades 32:21, 129:7, 179:7, 189:15 december 57:4, 57:10 decent 40:16, 40:20, 41:4, 41:16 decide 26:7, 31:8, 54:20, 55:1 decided 28:1 decision 48:19, 54:4, 99:14, 183:12, 183:16, 183:19, 183:22, 184:21 decisions 44:6, 44:13, 45:2, 67:4, 99:21, 101:5 declaration 8:18, 8:20, 11:14, 11:19, 11:21, 14:3, 14:4, 14:18, 15:1, 15:3, 15:17, 16:20, 141:2, 146:4, 158:21, 159:1, 159:5, 159:9, 159:12, 159:17, 159:20, 160:9, 162:1, 162:7, 162:14, 163:21, 164:4, 164:11, 164:20, 165:1, 165:14, 167:4, 168:4, 171:1, 173:21, 174:4, 174:7, 174:8,	174:11, 175:2, 175:8, 175:9, 176:8, 179:1, 179:3, 181:3, 181:6, 181:13, 182:1, 183:1, 183:4, 183:20, 186:7, 187:10, 193:12, 194:6, 194:10, 197:22, 198:4, 198:15, 199:20, 208:14, 209:13, 209:20, 210:4, 210:8, 211:2, 215:16, 215:20, 232:19, 232:21, 233:6, 233:22, 237:4, 239:13, 244:11, 244:15, 244:16, 245:17, 247:4, 247:15 declarations 11:17, 11:18, 158:7, 158:14, 165:3, 175:8, 175:13, 175:22, 176:5, 179:14 declared 57:6 declined 126:12 decreasing 191:16 deemed 182:10 defense 144:19 defer 108:6, 108:10, 109:3, 137:15, 141:3 define 21:18, 66:19, 95:11, 125:8, 188:16, 188:18 defined 95:12	defining 26:11 definition 147:1, 183:12, 184:3, 184:5, 184:8, 184:10, 184:11, 184:20, 185:1, 185:18, 185:19, 185:22, 232:15 degradation 33:17, 88:5, 105:19, 112:22, 113:12, 114:1, 114:10 degrade 93:14, 113:21, 116:5 degraded 114:4, 114:5, 114:6, 114:9, 116:2, 189:22, 190:3 degree 185:11, 185:15, 254:1 deleted 150:5, 259:14 deliberate 126:1 deliver 46:10, 53:18, 53:21, 54:1, 54:5, 54:20, 55:1, 56:14, 86:9, 101:14, 102:1, 102:19, 103:12, 103:20, 106:12, 106:21, 107:1, 107:6, 108:18, 109:5, 110:11, 112:8, 112:13, 115:19, 131:5, 192:15, 202:7, 203:6, 212:13, 227:17 delivered 46:21, 48:21,	83:6, 192:6, 221:21, 236:16, 237:7 delivering 106:1, 106:6, 116:11, 116:18, 225:22 delivery 32:9, 32:15, 33:10, 33:21, 34:2, 46:9, 46:12, 47:7, 47:12, 48:1, 48:3, 48:6, 48:7, 48:17, 49:2, 52:6, 52:20, 53:5, 53:7, 53:8, 53:13, 53:19, 54:9, 55:12, 55:16, 56:15, 56:19, 88:1, 88:8, 102:13, 104:16, 105:8, 105:20, 111:18, 114:17, 115:13, 116:22, 185:13, 185:15, 191:18, 192:5, 192:11, 192:15, 192:16, 192:22, 193:3, 193:8, 193:15, 194:1, 194:4, 194:5, 195:12, 197:19, 198:22, 269:2, 270:7 delta 149:3, 152:3, 152:15, 259:16, 261:1 demonstrate 103:11, 114:4, 114:12, 130:15, 195:11, 197:3, 227:17 demonstrated 47:11, 61:21, 67:18, 73:19,
---	---	--	--

252:14 demonstrating 54:17, 196:13, 196:15, 196:21, 252:4, 259:19 department 7:22 depended 180:13, 264:8 depending 25:14, 114:5, 189:2, 208:2, 226:17, 230:12, 254:2, 271:22 depends 21:3, 21:8, 29:22, 30:16, 52:12, 83:2, 106:9, 119:19, 161:3, 187:1, 188:16, 188:18, 265:22 deposed 8:3 deposit 116:8 deposition 1:18, 2:1, 5:9, 8:7, 14:1, 15:4, 16:21, 17:2, 122:10, 277:6, 277:8, 277:14, 277:16 derive 220:14, 244:14 derived 241:16 describe 110:20, 159:22 described 39:13, 45:17, 54:17, 96:10, 117:19, 139:5, 184:19, 184:22, 185:5, 239:2, 256:5, 256:11 describes 145:22, 146:2,	212:12, 216:17 describing 47:16, 59:1, 110:22, 148:16, 223:8, 223:11 description 150:1 design 39:12, 45:2, 67:4, 67:13, 74:11, 78:7, 78:11, 78:15 designed 20:10, 21:10, 23:11, 25:3, 26:15, 27:5, 27:9, 52:19, 57:16, 57:21, 61:22, 74:22, 132:18, 139:10, 141:14, 141:16, 265:4, 265:6 designing 44:7, 44:13 desired 144:21 despite 238:8 detail 77:11, 158:7 details 9:7, 135:12 detectable 274:15 detected 227:1 detecting 19:13 determine 25:8, 26:10, 29:13, 120:11, 121:3, 121:7, 128:19, 150:13 determining 121:9 develop 21:15, 226:18, 246:8, 261:3,	265:14, 271:16, 272:8, 275:13 developed 30:20, 37:9, 54:15, 59:12, 60:5, 60:18, 60:19, 61:5, 61:13, 62:12, 62:19, 64:6, 64:13, 68:8, 104:17, 105:10, 106:15, 107:6, 141:22, 251:2, 259:16, 261:16, 261:22 developers 251:3 developing 32:9, 62:6, 67:5, 67:14, 198:19, 253:2, 256:20 development 59:2, 66:9, 66:17, 69:1, 69:3, 69:8, 69:10, 71:16, 76:16, 88:3, 88:8, 96:15, 100:11, 101:9, 101:12, 118:9, 126:2, 143:1, 143:7, 143:16, 152:15, 186:11, 200:5, 202:2, 206:4, 230:18, 231:6, 232:1, 251:18 differed 48:12 difference 242:9, 274:3, 275:1, 275:8, 275:9 differences 242:11, 270:2, 274:4 different 20:7, 24:9,	25:8, 25:12, 26:5, 26:10, 28:16, 28:22, 29:5, 32:8, 33:10, 33:21, 47:19, 48:20, 50:18, 65:4, 65:6, 66:1, 66:2, 66:14, 93:13, 100:10, 100:11, 108:11, 113:18, 117:14, 119:17, 119:21, 121:1, 122:5, 124:4, 126:21, 133:8, 133:16, 133:17, 137:6, 149:6, 150:3, 156:15, 160:6, 160:18, 160:20, 163:2, 182:20, 193:20, 194:2, 194:4, 197:19, 201:14, 204:4, 206:9, 206:16, 206:22, 207:19, 210:21, 213:2, 223:4, 223:5, 223:16, 223:22, 224:10, 224:15, 224:17, 225:2, 225:10, 228:15, 230:10, 230:11, 230:12, 237:11, 240:12, 243:20, 244:2, 245:7, 245:12, 248:17, 258:5, 261:18, 265:9, 266:5, 269:2, 269:3, 270:5, 270:7, 270:14, 270:21, 271:1, 271:3, 271:8, 272:6, 273:4, 273:6, 273:11, 273:13, 275:11, 275:12, 275:15
--	--	---	--

<p>differently 25:14, 27:21, 28:5, 28:10, 29:17, 110:22, 206:17, 207:2, 207:20</p> <p>difficult 19:10, 172:15, 173:10, 177:18</p> <p>diminishing 94:20</p> <p>direct 128:5, 130:3, 131:1, 224:1, 232:21, 239:1, 247:6, 266:16, 267:5, 267:10, 272:12</p> <p>directed 153:18, 156:3, 156:14</p> <p>directing 238:5</p> <p>direction 235:7</p> <p>directly 77:22, 188:5, 188:10, 192:3, 207:10, 211:1</p> <p>director 8:1, 18:22</p> <p>disagree 184:14, 242:7, 244:12</p> <p>discern 162:21, 163:5, 163:7</p> <p>disclose 235:14, 235:16, 239:15</p> <p>disclosed 124:14, 124:18, 181:15, 210:10, 211:14, 225:16</p> <p>discloses 209:15, 209:22, 212:9, 212:18, 222:22, 224:6,</p>	<p>224:20, 225:2, 225:5, 242:4</p> <p>disclosing 224:9</p> <p>disclosure 125:4, 139:14, 182:15, 182:17, 182:19, 182:22, 220:17, 221:15, 226:9, 234:2, 234:5, 268:19</p> <p>disconnect 112:2</p> <p>discover 128:13</p> <p>discovered 32:12, 58:10, 86:9, 101:13, 101:22, 140:16, 202:6, 203:5</p> <p>discovery 93:7, 128:14</p> <p>discuss 49:9, 49:18, 52:15, 71:20, 131:14, 131:19, 141:4, 247:9, 258:2</p> <p>discussed 24:14, 64:15, 101:9, 138:6, 139:15, 140:18, 146:4, 202:4, 209:13, 220:18, 225:9, 249:7</p> <p>discusses 131:15, 181:4, 181:8, 204:19</p> <p>discussing 53:3, 63:21, 64:5, 68:7, 111:17, 112:18, 116:21, 179:13</p> <p>discussion 98:22, 103:19, 248:6, 265:3</p> <p>disease 57:5, 98:17,</p>	<p>142:21, 143:5, 152:22, 176:19, 246:14, 248:11, 248:21, 249:10, 250:21, 251:5, 251:11, 252:6, 252:12, 252:18, 252:22, 254:1, 257:2, 259:21, 260:3, 260:6, 260:17, 260:18, 261:8, 263:2, 271:13, 271:22, 272:9</p> <p>diseases 5:19, 18:19, 18:21, 28:17, 75:15, 81:5, 81:8, 81:13, 81:14, 82:1, 100:8</p> <p>disorders 5:19, 75:15</p> <p>dispute 185:17, 212:8, 212:18, 222:22, 224:6, 224:19, 225:5</p> <p>disputed 222:4</p> <p>disputing 225:1</p> <p>disregarding 238:7</p> <p>distinct 24:8, 271:3</p> <p>distracted 92:10</p> <p>distracting 92:13</p> <p>dlin-kc-dma 138:1</p> <p>dlin-kc2-dma 136:8, 139:17</p> <p>dlin-mc3-dma 136:8, 139:17</p> <p>dlinDMA 110:5, 110:7,</p>	<p>110:13, 110:15, 112:6</p> <p>dna-based 29:20, 31:16</p> <p>dnas 197:20</p> <p>document 35:5, 111:22, 137:8, 160:5, 161:3, 168:22, 169:8, 169:22, 170:6, 172:13, 173:9, 203:13, 208:21, 209:5, 216:17, 238:10</p> <p>documents 6:13, 174:14, 177:17, 178:16, 178:18, 200:20, 216:12, 244:2</p> <p>dodge 20:12</p> <p>dogma 146:5, 146:9</p> <p>doing 27:5, 253:11, 262:3, 269:21, 270:4</p> <p>domain 59:14, 60:7, 62:14, 62:20, 68:10, 144:9, 156:22, 177:16, 229:17</p> <p>domains 161:17</p> <p>done 31:5, 36:4, 36:17, 47:2, 56:16, 61:1, 63:3, 131:10, 194:18, 208:16, 212:6, 217:1</p> <p>dorr 2:4, 4:6, 277:18</p> <p>dosage 121:3</p>
--	---	--	---

dose 119:17, 119:21, 120:2, 120:8, 120:10, 120:11, 120:18, 120:20, 121:7, 122:3, 193:4, 193:5, 228:8, 236:17, 237:6, 237:8, 237:15, 237:21, 238:17, 238:19, 239:3 doses 120:6, 120:7, 121:14, 121:22, 237:11, 238:3 dosing 120:11, 121:10, 121:13, 238:5 doubt 88:22 down 53:2, 58:3, 70:19, 93:19, 97:20, 109:9, 109:16, 110:3, 112:19, 115:3, 127:17, 164:5, 176:21, 218:3, 237:2, 255:11, 267:3 dozen 268:14 dr 7:9, 19:3, 89:20, 108:11, 109:3, 185:17, 190:21, 254:13, 266:20, 267:4, 267:10, 267:15, 276:5 draft 19:3, 76:8, 76:12, 100:20, 100:22, 101:3, 161:1, 161:22, 162:2, 162:8, 162:20, 163:5,	166:16, 169:12, 171:13, 171:22, 172:12, 172:17, 173:1, 173:6, 173:11 drafted 166:9, 166:20, 167:1 drafting 175:7 drafts 160:7, 165:13, 170:11, 173:15, 174:14 draw 202:18, 202:20, 202:21, 262:10, 263:10, 264:16 drawn 202:21 drew 55:10, 55:22, 84:5, 89:15, 93:3, 97:4 driven 126:21 drives 271:2 driving 252:15, 253:12, 265:16 drove 253:8 drug 185:12, 185:15 dspc 136:9, 138:2, 139:22 du 69:5, 70:5, 70:11, 71:11, 71:19 due 19:12, 33:14, 209:10, 250:2, 263:1 duly 7:3, 277:7	during 70:14, 71:1, 71:8, 112:20, 184:20, 186:10 <hr/> E <hr/> e 128:4, 130:2 each 11:14, 19:15, 25:11, 28:5, 149:13, 164:6, 175:3, 181:14, 209:15, 209:22, 210:9, 211:13, 228:19, 271:7 earlier 41:10, 78:22, 81:6, 90:18, 94:12, 107:4, 114:20, 122:4, 164:7, 170:11, 190:22, 254:16, 257:20, 265:3, 266:3, 274:6 earliest 74:19, 104:3 early 13:15, 32:10, 32:17, 57:13, 90:19, 96:15, 129:8, 198:18, 199:14, 249:22, 269:16 easier 115:11 easily 228:9, 232:4 east 73:9, 142:20, 143:4 eastern 143:12 easy 21:5, 197:5, 197:6, 228:9, 232:5 edit 162:21, 168:14	edited 165:10, 167:1, 167:22, 169:3, 169:19, 170:19 editing 165:13 editor 76:10, 85:12, 101:1, 101:4 edits 76:11, 168:18, 170:12, 171:10, 172:3 effect 100:19, 248:18 effective 20:16, 42:3, 94:19, 99:9, 142:22, 143:6, 143:15, 153:10, 154:3, 196:8, 255:6 effectively 129:14 effectiveness 262:12 efficacy 25:11, 274:8 efficiency 193:22, 195:12 efficient 114:17, 116:22, 188:8, 188:13, 188:16, 188:19, 191:17, 192:5, 192:16, 192:22, 193:3, 193:8, 193:15, 205:19, 206:1 efficiently 192:14 efforts 144:6, 144:8, 194:19 eight 79:14, 80:2, 80:16, 81:20, 82:3, 115:3,
---	---	---	---

203:2, 203:21 either 25:5, 78:12, 80:21, 114:4, 147:15, 148:4, 181:15, 207:10, 209:16, 210:1, 210:10, 210:17, 211:14, 211:20, 258:20 elaborate 51:16, 123:18, 133:10 elderly 118:17 elected 53:22, 72:2 electrophoresis 112:19 elements 29:1, 47:2, 48:7, 204:19, 204:22, 205:12, 205:15, 220:15 elicit 52:8, 106:8, 145:16, 147:11, 212:19, 221:18, 240:16, 240:18, 241:3 elicited 256:6, 261:3 eliciting 220:19 elicits 222:5 else 14:12, 15:6, 15:13, 15:18, 16:18, 17:13, 161:2, 163:11, 167:9, 175:11, 261:12 email 13:10 embodiment 224:2 emerge 21:9, 22:12,	74:15, 131:21, 144:2, 201:3 emerged 20:6, 21:2, 22:20, 57:4, 57:9, 74:6, 74:10, 125:20, 131:20 emergence 142:19, 143:3, 143:12 emerging 22:8, 22:17, 30:21 employed 7:17, 7:18, 277:24 enable 74:18 enabled 97:10, 200:3, 201:22 enabling 182:3, 182:15, 182:17, 182:22 encapsulate 105:17 encapsulated 197:16, 234:3, 234:6 encapsulating 223:12 encapsulation 114:16, 115:6 encode 25:17, 25:20, 26:2, 26:5, 26:8, 26:22, 30:7, 30:11, 31:9, 31:17, 77:12, 77:14, 133:4, 133:9, 133:21, 133:22, 141:7, 212:13, 222:2, 222:14, 240:14 encoded 22:16, 31:19,	39:17, 39:21, 40:11, 43:1, 45:6, 77:18, 77:22, 78:3, 79:1, 97:12, 188:9, 188:15, 248:7, 262:12 encodes 106:10 encoding 37:11, 38:8, 38:11, 39:2, 53:9, 53:14, 53:15, 53:19, 54:2, 54:6, 57:17, 57:21, 66:18, 67:20, 71:20, 72:3, 77:16, 78:12, 78:15, 94:5, 118:6, 130:22, 132:21, 145:22, 146:3, 146:10, 146:11, 153:7, 207:11, 212:9, 222:17, 236:16, 239:16, 247:20 encompassed 65:3 end 146:18, 161:20, 170:16, 171:11, 172:4, 172:15, 176:4, 176:7, 230:8, 262:20, 271:6 ended 45:9, 260:9 endpoints 274:8 ends 238:2 enforce 263:12 engage 217:10 enhance 52:20, 94:19,	152:21, 248:21, 252:5, 254:1, 261:21 enhanced 63:10, 63:13, 95:7, 248:11, 249:10, 250:20, 251:5, 251:11, 252:9, 252:12, 252:18, 252:22, 259:20, 260:3, 260:6, 260:16, 260:18, 261:8 enhancement 152:13, 152:16, 176:19, 246:14, 251:15, 263:1 enough 43:8, 95:20, 100:17, 157:6, 236:17, 237:8, 238:3, 238:17 ensure 36:4 entail 22:1 enter 189:14 enthusiasm 81:2, 84:2, 126:12, 127:2 entire 100:2, 139:3, 142:13, 162:8, 166:4, 166:16, 168:22, 169:18, 169:22, 170:6, 171:8, 171:19, 186:13, 195:5, 198:3, 238:20, 268:12 entirely 22:1, 117:17, 128:7, 150:2, 203:10, 230:12, 271:8, 273:10, 275:11, 275:15 entirety 237:18
---	--	--	--

entry 58:11, 71:15, 187:18, 188:2 envelope 40:1, 45:5 envisioned 201:8, 201:10, 204:2 enzyme 58:6 epidemic 60:21, 61:2 epithelial 58:7 epitopes 27:7, 119:5, 260:14, 260:15 equal 80:22 equally 27:16, 48:20 era 201:4, 201:18 escalation 120:10 especially 189:2, 251:13, 261:4 esq 3:5, 3:6, 3:13, 3:14, 4:4, 4:5 essentially 47:15, 221:11 establish 99:20 established 68:1, 82:19, 130:8, 130:11, 241:22, 251:1, 252:17, 258:16 estimation 245:10, 268:8 etr 135:2 evaluate 46:5, 141:2 evaluated 118:6	evaluation 5:20, 143:8, 257:16 even 9:11, 27:21, 44:21, 60:22, 90:21, 94:14, 96:16, 119:2, 126:8, 127:5, 129:12, 149:18, 169:5, 170:9, 170:16, 195:2, 195:3, 195:17, 196:13, 196:14, 197:13, 197:20, 201:7, 203:21, 203:22, 213:7, 222:16, 231:12, 253:10, 253:11, 271:9, 273:9, 274:14 event 126:7 eventually 201:3, 204:3, 204:5, 260:22 ever 8:5, 144:2, 269:12 every 9:15, 9:16, 36:4, 65:20, 164:18, 165:8, 166:10, 166:16, 166:21, 181:14, 201:1, 209:15, 209:22, 210:9, 210:15, 211:13, 211:18, 275:13 everybody 126:14, 253:2, 269:10 everyone 14:6, 14:15, 269:7 everything 101:5, 125:9, 125:10, 160:10,	161:18, 161:20, 175:16, 220:14, 230:8, 270:8 evidence 40:15, 41:15, 41:21, 63:9, 71:10, 152:11, 205:15, 215:11, 235:2, 246:13, 246:14, 248:11, 261:19 exact 135:10, 275:16 exactly 58:16, 134:3, 165:9, 180:9, 211:1, 249:17 examination 5:3, 7:6, 254:10 examined 7:4 example 15:10, 22:4, 28:18, 30:2, 46:20, 46:21, 47:4, 62:1, 63:4, 121:17, 132:2, 132:3, 132:14, 133:4, 134:6, 134:9, 134:12, 134:14, 135:13, 136:2, 136:17, 136:20, 136:22, 137:3, 138:15, 139:3, 139:7, 141:6, 161:6, 161:11, 163:18, 167:15, 176:1, 178:10, 186:14, 186:20, 188:17, 189:10, 196:22, 197:1, 197:11, 206:15, 208:11, 217:9, 226:19, 226:21, 227:4, 227:6, 227:7, 227:8,	227:11, 236:14, 248:9, 250:16, 250:19, 258:21, 273:7 examples 124:22, 132:1, 132:9, 132:12, 135:17, 136:16, 137:2, 137:20, 166:2, 176:12, 212:16, 213:8, 214:8, 216:19, 217:22, 218:22, 219:2, 219:6, 256:3 except 270:9 excerpts 75:18 excited 61:2, 269:10 exciting 269:7, 270:18, 271:10 excuse 37:4, 70:8, 77:4, 85:14, 87:11, 91:9, 103:8, 110:4, 212:1, 217:4 exemplified 255:20, 256:15 exhibit 5:10, 5:11, 5:16, 5:20, 6:3, 6:4, 6:5, 6:6, 6:7, 6:8, 6:9, 6:10, 11:22, 12:3, 18:2, 18:5, 35:1, 35:4, 69:21, 69:22, 70:2, 70:4, 71:19, 75:7, 75:12, 88:13, 88:16, 94:4, 102:6, 102:7, 102:10, 104:21, 108:19,
--	--	---	---

109:6, 110:11, 112:9, 112:13, 142:1, 142:5, 177:3, 198:1, 198:2, 198:3, 198:8, 198:10, 198:14, 208:21, 209:1, 239:4, 239:7, 249:22, 251:21, 257:13, 262:11 exhibiting 248:17 exhibits 5:9, 6:1, 122:15, 158:9, 257:14 exist 22:2, 157:3 existed 106:17, 195:14 expanded 18:18 expect 40:20, 41:4, 50:22, 51:8, 78:18, 130:21, 131:4, 272:18 expectation 45:18, 49:10, 49:19, 50:3, 50:5, 50:16, 51:5, 244:19 expected 47:20 experience 32:1, 32:4, 66:7, 66:15, 184:22, 185:7, 185:12, 185:15, 185:20, 186:1, 186:3, 186:4, 259:8, 266:16, 267:5, 267:11, 267:15, 268:8, 268:9, 268:11, 272:12, 273:1 experiment 28:3, 50:19,	55:4, 121:17, 150:12, 230:9, 248:3, 252:6, 252:13, 253:11, 262:4 experimental 59:12, 60:4, 60:17, 61:5, 61:13, 68:8, 141:22, 196:2, 228:6, 228:20, 228:22 experimentation 246:18 experimented 258:6 experiments 27:4, 29:22, 32:19, 32:20, 33:4, 41:7, 45:22, 49:7, 55:18, 121:7, 122:1, 128:18, 136:3, 138:18, 138:22, 197:10, 251:7, 266:3, 266:14 expert 108:11, 124:12, 141:4, 231:11, 266:20, 272:11 expertise 24:1, 161:10, 231:13 expires 277:31 explain 28:12, 150:22, 151:3, 192:2, 203:15, 230:17, 248:5 explained 218:14, 230:22, 249:6 explains 110:3 explicitly 210:17, 211:20,	238:9 exploration 249:19 explore 63:11 explored 63:14, 107:12, 152:14 express 27:12, 39:11, 52:6, 52:7, 83:15, 131:11, 141:15, 141:16, 213:3, 227:18 expressed 39:9, 47:20, 193:7, 228:1, 230:13, 268:2 expresses 52:3, 90:4, 234:6 expressing 33:7, 33:9, 46:6, 47:4, 50:10, 50:22, 51:8, 52:13, 79:2, 217:8, 263:9 expression 38:19, 39:3, 46:6, 47:1, 48:7, 78:2, 130:16, 188:9, 188:14, 191:20, 192:17, 193:1, 193:9, 193:17, 194:1, 195:12, 207:3, 208:8, 231:14, 231:15, 231:21, 233:3, 233:19, 263:11, 263:16, 264:8, 264:10, 264:14, 265:17, 265:18, 265:20, 267:19 expressly 181:16, 209:16, 210:1, 210:11,	211:15 extent 137:11, 221:3, 233:9 <hr/> F <hr/> facilitate 34:9, 105:18, 105:20 facilitating 260:5 fact 35:16, 83:6, 90:8, 98:18, 122:4, 146:6, 156:16, 196:13, 208:1, 222:16, 238:8, 239:15, 266:3 fail 33:13 failed 32:20, 33:4, 274:13 failures 85:3 fair 10:15, 10:16, 18:9, 18:11, 21:2, 21:7, 21:14, 27:15, 27:17, 29:18, 34:18, 36:5, 36:6, 36:9, 36:16, 36:19, 38:21, 43:8, 44:7, 44:14, 45:20, 48:22, 49:1, 51:2, 51:10, 53:20, 59:2, 61:4, 63:7, 71:4, 73:20, 78:17, 79:20, 80:18, 83:1, 89:19, 91:14, 99:15, 105:22, 116:10, 119:18, 119:20,
---	--	--	--

121:1, 121:4, 128:22, 130:20, 133:12, 134:4, 136:15, 137:1, 150:7, 154:21, 156:4, 157:6, 167:21, 170:3, 188:12, 188:20, 200:8, 200:13, 205:11, 214:4, 218:7, 219:21, 220:8, 223:13, 228:21, 249:11 fairly 119:4, 130:7, 223:16 fall 12:13 familiar 35:5, 36:7, 36:10, 40:13, 41:11, 103:3, 105:13, 119:7, 119:9, 142:9, 142:14, 142:18, 152:14, 161:12, 198:12, 211:21, 214:2, 247:12 familiarity 118:12, 118:14 far 83:13, 194:20, 267:9 fatty 105:17 favor 98:4 avored 44:1, 262:22 fda-approved 119:8 february 122:20 feel 231:9, 233:8 feline 250:1 few 62:17, 109:9,	134:5, 143:21, 194:6, 195:10, 243:20 field 16:1, 32:10, 57:16, 57:20, 61:6, 78:11, 98:10, 126:13, 126:19, 129:3, 179:9, 185:20, 189:19, 194:7, 194:16, 194:21, 195:18, 197:18, 242:18, 246:1, 246:4, 251:12 fields 200:4, 202:1 figure 103:14, 107:22, 108:1, 108:2, 108:3, 109:21, 110:15, 110:20, 111:2, 111:8, 111:12, 111:21, 112:1, 112:3, 112:4, 112:7, 112:10, 112:15, 113:8, 113:15, 113:16, 117:2, 135:21, 147:7, 149:2, 149:4, 186:15, 252:2, 258:22, 260:9, 262:11 figures 135:20, 251:9, 253:18 filed 122:19, 123:1, 123:2, 123:15, 214:8 filing 123:9 final 76:6, 76:9, 85:11, 100:22, 101:5, 162:20, 163:5, 165:10	financially 277:26 find 30:2, 66:5, 121:6, 133:5, 169:13, 180:3, 220:6, 250:7, 254:21 finding 262:20, 270:11, 274:5 findings 94:18 fine 56:8 fine-tune 228:11 finish 177:7 first 12:7, 17:16, 17:18, 31:13, 41:8, 49:7, 57:3, 57:9, 57:13, 64:20, 71:12, 74:7, 76:14, 76:18, 77:17, 79:5, 79:7, 79:9, 84:3, 89:12, 94:3, 96:10, 104:3, 106:14, 122:18, 127:22, 128:13, 128:18, 132:5, 143:11, 144:19, 161:1, 161:22, 162:2, 162:8, 169:12, 171:13, 171:22, 172:12, 173:1, 173:6, 197:7, 199:5, 199:7, 199:9, 199:10, 199:12, 211:9, 232:3, 232:6, 249:18, 268:19, 269:6, 274:20 firsthand 266:16, 267:11,	272:12 five 23:20, 179:21, 179:22 fix 109:19 flu 50:14, 50:15 focus 32:22, 90:4, 97:4, 139:13, 245:15, 262:2 focused 26:18, 62:17, 90:2, 96:8, 103:13, 144:8, 194:21, 197:19, 244:22, 248:10, 270:1 focuses 218:18 focusing 97:4, 101:20 folded 79:2 folder 177:15 follow 193:14, 262:18 followed 196:3, 259:1 follows 7:5 forefront 129:17 form 40:22, 44:8, 48:13, 49:13, 51:4, 51:11, 61:9, 62:9, 64:3, 65:12, 91:15, 92:8, 94:7, 95:9, 96:5, 97:5, 107:7, 116:13, 136:19, 140:21, 145:8, 147:2, 148:21, 150:21,
--	--	--	--

151:9, 156:5, 171:6, 173:2, 178:5, 181:22, 189:8, 191:6, 191:21, 200:14, 202:9, 203:12, 206:18, 207:21, 212:11, 218:1, 223:14, 224:8, 228:2, 229:1, 229:15, 230:20, 232:14, 232:18, 233:5, 233:21, 234:8, 238:11, 242:12, 255:9, 255:22, 256:8, 263:18, 264:3, 264:19, 266:8, 267:1, 267:6, 267:13, 272:13, 272:19, 273:20 formatting 160:19 forming 239:10 forms 114:8 formulate 90:15, 225:16 formulated 52:18, 66:2, 67:20, 153:9, 196:22, 197:11, 224:10, 225:10, 248:1, 248:8 formulating 191:18, 223:1, 224:7, 224:20, 225:5, 226:3 formulation 47:12, 48:2, 48:6, 49:3, 54:9, 54:13, 104:4, 104:7, 111:10, 111:14, 112:21, 118:5, 136:4, 136:5, 138:22, 139:1,	140:9, 223:9, 224:2, 228:8 formulations 113:2, 117:14, 117:18, 135:18, 136:18, 137:4, 137:21, 139:5, 140:17, 141:5, 194:3, 223:4, 223:6, 223:11, 223:17, 223:22, 225:2, 225:11, 225:20, 225:21, 225:22 forth 165:12, 277:6 forward 45:9, 47:21, 48:19, 129:4 found 116:4, 167:11, 175:21, 175:22, 186:14, 186:19, 186:21, 210:16, 211:19 foundation 88:21, 91:4, 91:16, 92:1, 92:9, 99:18, 99:20, 102:16, 107:8, 234:16 foundations 165:22 four 55:19, 76:5, 108:3, 109:16, 110:3, 112:18, 156:16, 163:10 fpiv 250:10 fragments 169:6 frame 34:1, 61:5, 61:13, 61:17, 74:1, 75:1, 153:7 framed 218:16	free 34:8 friday 1:21, 277:20 front 79:9, 89:6, 101:8, 122:22, 207:6 fruition 32:13 full 7:11, 7:13, 17:9, 17:10, 17:11, 260:20, 262:18, 267:21 full-length 132:21, 141:7, 141:11, 145:15, 147:10, 147:18, 148:6, 148:13, 148:18, 149:5, 150:5, 151:16, 152:1, 152:12, 242:14, 248:12, 259:13, 259:20, 260:10, 260:13, 261:12, 261:14, 261:19 fuller 1:19, 2:1, 5:3, 5:9, 5:10, 7:2, 7:9, 7:13, 11:19, 18:2, 19:3, 35:1, 75:7, 142:1, 254:13, 276:5, 277:5, 277:17 fully 8:11, 8:14, 9:10, 119:9, 170:19, 171:5, 252:20 function 58:21, 59:4, 116:6, 116:10, 144:18, 206:16, 207:2, 207:19 functional 114:17, 117:1	fundamental 51:22, 268:4 funded 84:20 funding 126:20, 127:9 funga 18:18, 18:21, 241:5 fungus 240:19 further 58:4, 195:2, 237:2, 262:22, 263:1, 275:21, 276:4, 277:12, 277:16, 277:22 fuse 116:7 fusogenic 225:6, 225:18, 226:2, 226:5 future 21:1, 21:3, 21:16, 84:13, 85:5, 126:7 <hr/> G <hr/> g-csf 234:3 gained 129:2 gave 76:7, 80:6, 87:12, 90:22, 91:8, 91:11, 99:10, 101:11, 183:7, 203:1 geall 104:21, 107:21, 116:22, 236:10, 237:11, 237:17, 237:21, 238:8, 239:8, 239:15, 239:18, 242:3, 244:6, 244:18, 245:5, 245:6 gears 158:3, 257:12,
---	--	---	---

266:2 gel 112:19 gene 34:4, 34:6, 46:21, 52:5, 55:15, 74:12, 81:15, 81:17, 95:1, 96:4, 96:18, 96:19, 98:8, 192:9, 192:13, 197:20 gene-based 76:15, 77:1 general 15:21, 43:18, 58:12, 58:15, 66:13, 68:22, 77:8, 77:9, 108:14, 133:12, 133:13, 134:2, 141:20, 144:15, 155:5, 155:14, 177:15, 194:18, 204:1, 253:8 generally 76:4, 145:1, 179:16, 187:6, 226:18, 242:14, 242:19 generate 97:2, 97:7, 98:3, 148:8, 245:1 generated 20:13, 60:14, 73:15, 147:17, 259:22 generating 19:15 generation 62:2, 98:16 generic 213:5, 213:10, 242:12, 242:16, 243:6 genes 77:16	genetic 5:19, 75:15, 78:6, 78:14, 81:14 genome 177:12, 178:2 getting 127:8, 152:18, 193:4, 204:10, 214:1, 226:13, 229:17 gfp 227:7, 227:8 giant 113:10 give 10:2, 45:22, 52:7, 120:12, 122:12, 150:14, 176:12, 219:19, 267:3, 275:18 given 33:7, 78:5, 120:9, 121:18, 133:9, 133:21, 135:14, 144:21, 163:9, 165:8, 170:16, 193:5, 227:18, 229:5, 230:8, 275:17, 277:10 gives 238:18 giving 92:6, 92:16, 163:18 glycoprotein 144:10, 241:10 go 9:7, 23:8, 30:14, 30:18, 52:14, 56:18, 56:21, 64:4, 68:3, 72:8, 74:5, 79:3, 83:13, 91:5, 94:16, 101:7, 102:4, 110:2,	121:14, 131:22, 140:22, 142:8, 153:1, 160:10, 165:18, 166:3, 166:6, 169:18, 170:10, 170:22, 175:6, 177:9, 179:13, 186:6, 189:13, 192:1, 205:17, 208:1, 208:13, 211:7, 212:1, 217:16, 222:19, 223:2, 223:7, 228:4, 229:22, 230:5, 230:13, 235:8, 235:9, 235:10, 238:19, 239:21, 246:19, 257:11, 263:4, 270:20, 276:1 go-to 179:8 goal 59:15, 60:7, 68:10, 150:10, 256:18 goes 61:3, 72:11, 85:11, 101:4, 105:19, 124:8, 126:16, 165:12, 201:13, 210:18 going 9:9, 13:11, 26:1, 29:13, 49:8, 49:17, 50:13, 50:14, 50:17, 64:22, 66:12, 75:3, 84:4, 84:17, 92:22, 102:6, 108:5, 108:6, 116:4, 120:11, 120:19, 120:21, 122:12, 135:20, 145:14, 149:1, 150:14, 160:4,	161:9, 161:20, 163:17, 166:16, 169:22, 191:22, 192:2, 194:19, 200:20, 202:10, 204:7, 213:6, 214:16, 220:6, 229:8, 230:7, 238:18, 242:22, 243:1, 246:4, 253:10, 254:13, 258:18, 259:10, 260:13, 265:11, 265:15, 265:16, 268:18, 269:12, 271:5, 271:18, 271:19, 271:20, 272:3, 273:9, 275:6 gone 158:4, 167:22 good 7:9, 7:10, 22:13, 30:4, 226:21, 227:8, 274:16, 275:3 googling 43:6 graduate 269:22, 271:14 graham 142:17 graham's 261:17, 262:1 grant 160:2, 160:8, 160:16, 160:17, 160:22, 161:8, 172:14, 173:9 greater 195:18 greatest 195:9 green 230:5 greenberg 14:8 griffin 176:1, 185:17,
--	--	---	--

266:20, 267:4, 267:10 griffin's 267:15 group 23:21, 47:11, 259:15, 259:18, 261:10, 261:17, 262:1, 262:22 grouped 31:2 grouping 24:7 groups 147:18 guarantee 230:6 guess 137:9, 137:15, 149:1, 172:19, 172:20, 173:12, 174:9, 175:10, 180:7, 214:22, 221:13, 232:20 guesses 172:18 guides 235:6 gun 34:4, 34:6, 46:22, 52:6, 55:15, 192:13	142:4, 204:11 handing 88:15, 208:20, 239:6 hands 272:5 handy 56:20 hang 79:4 happened 56:6, 200:21, 201:9 harbor 269:4 hard 127:8, 162:21, 163:5 harder 169:17 hastings 3:7 head 10:4 head-to-head 33:6, 33:10, 55:5, 84:14, 273:3 heading 19:7, 76:14, 109:10, 110:2, 111:9, 117:22, 118:4, 127:12, 127:20, 132:14, 132:17, 136:2, 138:16, 138:17, 147:9, 204:15, 204:18, 221:7, 221:9, 221:16, 240:9, 249:19 healthy 178:13 hear 124:12 heard 38:2, 38:3, 192:1 held 2:2, 195:8,	270:9 help 108:13, 136:1, 221:7 helped 203:14 helper 252:7 hemagglutinin 50:15, 50:16 here 9:22, 10:17, 19:6, 23:17, 23:22, 24:11, 26:11, 31:3, 31:10, 35:12, 37:7, 37:9, 39:13, 46:16, 49:10, 49:19, 56:19, 65:1, 66:13, 85:20, 86:15, 97:15, 109:11, 113:11, 117:12, 122:22, 129:21, 137:7, 137:22, 138:4, 138:6, 139:9, 143:10, 145:15, 148:2, 148:16, 149:22, 150:13, 152:5, 164:1, 166:22, 169:6, 169:10, 172:20, 176:18, 177:22, 178:4, 184:9, 200:16, 202:12, 204:10, 204:11, 223:10, 223:16, 223:22, 224:9, 225:9, 226:7, 238:10, 239:18, 243:16, 258:6, 259:12, 260:8, 275:7 hereby 277:4 herein 127:13, 128:2	hereinbefore 277:6 hereunto 277:29 heterologous 149:16, 151:19, 259:3 high 108:15, 108:17, 137:17, 143:22, 147:11, 198:21, 231:14, 259:4 higher 97:17, 120:6, 120:22, 147:19, 148:19, 149:18, 150:8, 150:18, 151:6, 152:2, 152:8, 152:20, 258:19, 260:11, 260:19 highest 147:17, 149:15, 150:14, 152:5 highlight 58:22 highlighted 143:14 highlights 142:22, 143:6 highly 23:11, 26:16, 30:12, 143:20, 191:5, 191:11 historical 64:11 historically 64:10 hiv 5:18, 75:14, 178:11 hold 28:6, 83:15, 84:4, 140:20, 177:1 home 7:14 honest 180:7
H			
hale 2:4, 4:6, 277:18 half 56:22, 68:5, 268:14 hand 80:4, 82:7, 102:6, 112:17, 265:21, 265:22, 277:29 handed 18:4, 35:3, 70:4, 75:12,			

honestly 126:20, 172:18	I	immunized 33:16, 149:7, 150:1	62:16, 63:12, 63:15, 67:20, 120:4, 145:15, 150:3, 197:6, 222:14, 240:12, 241:15
hour 9:5, 9:16, 75:4	idea 74:17, 74:20, 74:21, 77:5, 99:7, 121:15, 121:21, 124:7, 128:14, 128:17, 156:20, 262:5	immunizing 139:12	immunology 268:5
hours 173:20, 173:22, 174:3, 174:8, 174:18, 175:1, 175:7, 179:12, 180:17	ideal 74:11, 74:15, 74:17	immuno 265:16	impact 93:10, 227:20
however 94:7, 189:15, 199:13, 199:18	ideas 124:9	immunogen 25:3, 25:14, 27:5, 27:9, 33:7, 33:9, 48:9, 48:20, 120:2, 121:18, 148:2, 150:14, 212:9, 222:2, 236:16, 240:10, 240:14, 240:15, 240:17, 241:3, 241:8, 241:20, 242:4, 242:7, 248:18, 248:21, 270:5, 270:9, 270:12, 271:17, 275:8, 275:11, 275:15	important 10:2, 71:16, 94:5, 114:2, 114:11, 145:2, 205:13, 205:16, 207:8, 207:15, 213:18, 256:19
huge 195:4, 274:22	identical 26:5, 26:22, 27:1, 27:2, 28:1, 29:10, 159:3	immunogenesis 189:6	improve 88:2
human 19:11, 19:13, 21:1, 21:7, 21:16, 72:12, 73:7, 85:3, 177:12, 178:2, 274:7	identification 18:3, 35:2, 75:8, 142:2	immunogenic 25:10, 45:11, 46:1, 94:9, 120:4, 212:14, 236:18, 237:9, 238:17	improved 27:8, 94:21, 96:2, 98:6
humans 21:13, 73:15, 84:22, 86:12, 203:8	identified 7:3, 21:17, 21:20, 27:7, 92:20	immunogenicity 52:21, 90:3, 90:9, 94:21, 118:2, 118:7, 130:17, 132:5, 132:19, 138:16, 139:11, 178:12, 190:4, 190:12, 191:3, 191:16, 198:21, 258:12, 265:8, 265:12, 265:18, 265:21	improvements 95:22, 96:1
hundred 143:21	identify 121:12, 170:8, 176:22, 178:3, 271:20	immunogens 26:6, 26:10, 45:8, 47:5,	inactivated 65:21, 195:21, 248:14, 250:19
hyperlink 86:4, 86:21, 87:2, 92:21, 101:21, 102:9, 102:18	igg 241:1		inadequate 19:17, 19:22, 23:2
hyperlinked 88:18, 89:1, 102:5, 102:8, 102:12, 102:21, 103:19, 107:4	imagine 236:8		inc 1:5, 1:8, 3:4, 3:12, 4:3, 7:7, 277:13
hypotheses 50:18, 51:13, 51:18, 51:21	immediate 187:9		incidence 189:17
hypothesis 26:18, 27:19, 28:4, 42:6, 50:1, 51:15, 52:3, 52:8	immunity 20:13, 70:14, 71:1, 71:8, 256:13, 256:19, 271:3, 273:10		incidences 252:21
hypothetical 184:18	immunization 149:13, 196:4, 250:2, 258:15, 259:2, 259:5, 259:6		include 62:1, 83:6, 115:21, 135:2, 135:6, 135:17, 136:5, 138:18, 140:9, 186:12, 213:5, 218:9, 225:17, 241:15, 242:17, 243:4
	immunizations 261:6		included 19:6, 67:9,

113:3, 130:1, 135:1, 137:19, 183:20, 198:14, 198:17, 199:19, 245:17, 259:12 includes 24:2, 28:7, 73:12, 134:12, 134:14, 134:18, 135:7, 187:6, 194:2, 214:8, 223:18 including 24:3, 58:7, 65:5, 81:14, 93:13, 195:19, 231:17, 241:1, 250:17, 251:7, 251:14, 253:15, 274:17 inclusion 191:10, 217:21 incomplete 209:18, 210:13 incorporate 63:22, 160:4, 166:18, 235:19, 236:2, 236:6 incorporated 59:13, 60:6, 62:13, 62:19, 64:6, 64:14, 68:9, 101:6, 108:20, 109:6, 110:12, 112:9, 112:14, 191:14, 237:17, 238:9 incorporates 236:10 incorporating 214:10 incorporation 89:6, 93:7, 95:7, 97:10, 237:20 incorrect 37:17 incorrectly 38:4, 38:5	increase 90:11, 190:6, 190:13, 193:22, 261:8 increased 89:8, 130:16, 191:15, 229:12, 265:17 increases 152:21 increasing 95:18, 100:16 independently 216:10 indicate 94:18 indication 189:3 indications 100:10 individuals 185:10 induce 26:15, 27:13, 29:15, 30:4, 30:8, 33:12, 45:19, 47:13, 49:11, 49:20, 50:1, 50:13, 51:1, 51:14, 51:18, 144:14, 145:6, 150:8, 152:5, 153:10, 154:2, 154:3, 154:15, 196:11, 196:19, 197:5, 253:5, 255:6, 256:19, 256:22, 258:20, 268:6, 268:21, 271:19, 274:9, 274:13, 274:19, 274:21 induced 48:2, 56:10, 64:1, 65:11, 65:16, 147:19, 148:19, 150:17, 151:6, 152:2,	197:12, 260:11, 270:15, 270:17, 273:7 induces 5:12, 35:8 inducing 26:20, 30:3, 59:15, 60:7, 68:11, 253:19, 261:7, 271:21, 275:3 induction 61:21, 67:22, 70:12, 70:21, 71:6, 149:14, 274:17 ineffective 20:15 inefficient 198:22 infect 19:11, 38:14, 60:16 infected 73:16, 143:21, 178:11 infection 19:13, 21:1, 21:7, 21:16, 23:2, 40:18, 42:5, 57:6, 63:10, 70:14, 71:1, 71:8, 73:17, 144:18, 152:13, 152:17, 251:15, 251:17, 252:10, 261:21 infections 118:16 infectious 28:17, 81:5, 81:8, 81:13, 82:1, 100:8, 250:1 infectivity 63:13 infinite 121:14	influence 120:1, 120:7, 205:1 influenced 93:12 influenza 13:5, 13:6, 13:18, 19:9, 19:16, 19:21, 20:2, 20:10, 22:4, 22:5, 23:12, 25:16, 25:19, 26:2, 26:7, 28:2, 29:19, 30:13, 46:20, 47:4, 84:16, 84:17, 197:4, 197:14 information 25:22, 56:11, 125:13, 125:17, 135:15, 135:22, 160:4, 161:14, 161:15, 166:13, 173:18, 173:19, 180:4, 187:21, 219:17, 219:20, 220:12, 221:21, 221:22, 222:1, 222:3, 249:11, 264:10 informative 42:19 informed 44:6, 44:12, 61:6, 211:12 informing 48:18 inherent 87:21, 190:4, 190:12 inherently 87:19, 94:14, 181:16, 209:16, 210:1, 210:11, 210:17, 211:15, 211:20 initial 101:3, 123:10,
--	--	---	--

162:18, 163:4, 164:8, 167:17, 167:19, 197:3, 271:2 initially 104:5, 167:10 initiated 126:2 initiating 45:21 inject 52:4, 83:11, 90:16, 128:19, 213:2, 270:13 injected 39:8, 50:4, 50:7, 83:16, 90:21, 116:3, 146:13, 146:15, 146:22, 147:2, 192:6, 197:1 injection 39:7 innate 93:18, 271:3 innovation 200:2, 200:11, 201:21, 204:1 innovations 104:15, 105:8, 200:21, 201:7, 201:14 inorganic 52:18, 54:14 input 171:22 insert 25:5, 25:6, 25:15, 27:21, 28:8, 28:22, 47:18, 270:10, 270:11 insertional 189:6 inside 95:15, 95:16, 128:9, 188:4, 192:20, 193:6,	274:1 instability 86:3, 86:8, 86:14, 86:15, 86:18, 86:20, 87:6, 87:13, 87:22, 88:7, 88:18, 90:13, 91:1, 91:3, 91:9, 91:12, 91:14, 91:20, 92:5, 92:15, 100:13, 100:14, 198:21, 200:13, 202:6, 203:5 instances 11:19 instant 132:18, 139:10 instead 10:3, 186:13, 263:4 institute 177:12, 178:2 institution 183:12, 183:15, 183:18, 183:22, 184:21 instructing 234:10, 234:13 instructs 9:12 integration 189:18 integrity 112:20 intend 8:10 intent 238:22 interaction 73:5 interchangeabili- ty 266:5, 267:12 interchangeable 49:6, 206:10, 206:12, 266:18,	273:18, 273:22 interest 81:8, 81:16, 81:21, 128:6, 129:18, 130:5, 131:2, 187:19, 188:3, 196:1 interested 26:17, 277:26 interesting 229:3 interfere 60:15 interfering 104:16, 105:9 interim 7:22, 18:22 internal 187:3 interview 75:20, 76:2, 76:7, 80:7, 82:7, 87:12, 90:22, 91:8, 91:11, 92:6, 92:16, 99:10, 101:10, 107:5, 107:14, 202:22 interviewed 80:10, 85:9 intramuscularly 39:8 introduce 145:13 introduced 148:1 introducing 145:10 introduction 56:22, 57:2, 58:3 invalid 181:14, 209:10, 211:13 invention 123:10, 236:16, 240:14, 244:14 inventor 124:8, 214:9	inventors 128:12, 128:22, 129:22, 140:16 investigate 246:3, 262:17, 269:18, 269:19 investigated 252:14 investigating 204:4 investigator 35:20, 35:21, 160:8, 160:22, 248:19 investment 198:19, 199:15, 200:3, 200:12, 201:22 invitation 234:15 invokes 217:5 involve 13:8, 122:5, 265:11 involved 63:2, 71:14, 160:3 involves 11:3, 11:9 involving 43:10, 264:14 ionizable 109:13, 109:17, 110:4, 110:12, 112:1, 112:5, 153:13, 156:16, 156:21 ipr 1:11, 1:14, 10:21, 10:22, 11:2, 11:8, 234:9, 234:17 irrespective 29:19, 30:14 island 7:16 issue 216:6, 216:14,
---	---	---	--

219:7, 234:9, 243:15, 243:19 issues 90:20, 167:12, 195:11 itself 90:12, 92:22, 222:16, 258:20, 259:2	108:15, 108:17, 178:14 kevin 4:4, 12:16, 12:18, 14:6, 14:9, 17:17, 17:19 key 70:12, 70:21, 71:6, 274:3 keyboard 166:13 keywords 200:16 killing 98:20 kind 25:21, 32:12, 80:4, 81:21, 104:2, 121:14, 121:22, 126:13, 161:3, 166:3, 169:7, 176:13, 197:7, 201:12, 203:14, 264:8 kinds 192:14 kits 232:5 knew 50:9, 51:7, 104:6, 107:11, 107:15, 252:3, 252:8, 252:11, 253:7 know 10:12, 14:15, 27:6, 46:9, 46:13, 49:6, 50:21, 58:16, 78:6, 89:4, 92:21, 93:3, 106:16, 108:10, 109:1, 113:20, 120:17, 124:11, 134:1, 134:3, 134:12, 134:15, 134:18, 135:4,	135:8, 142:16, 151:11, 151:12, 156:13, 157:2, 160:19, 163:16, 165:4, 165:12, 166:7, 168:5, 169:21, 170:1, 170:17, 173:16, 173:17, 173:22, 174:2, 179:5, 179:12, 179:16, 180:2, 180:5, 204:10, 209:5, 212:6, 215:4, 215:6, 218:7, 219:10, 219:11, 219:13, 219:20, 220:7, 226:13, 229:20, 231:22, 233:12, 233:13, 243:7, 256:3, 256:17, 266:20, 267:9, 271:17, 271:18, 273:2 knowledge 66:5, 67:12, 71:22, 108:14, 127:14, 128:3, 129:1, 130:19, 233:9 known 59:5, 62:11, 62:18, 71:5, 73:21, 95:6, 130:18, 141:12, 141:13, 191:9, 192:10, 193:9, 193:17, 196:10, 196:18, 197:15, 205:22, 207:14, 213:1, 251:11, 251:12, 252:20, 252:21, 253:1, 261:18, 269:7 krinsky 3:13	68:2, 161:7, 266:15 labile 94:9, 94:11, 94:14 lack 33:14, 217:18, 252:12 lacks 88:21, 91:4, 91:16, 99:17 laid 166:8, 166:21 lamenting 127:8 language 19:5, 154:7, 154:13, 173:1, 213:5, 245:16, 255:6 large 189:19, 194:17, 236:17, 237:8, 238:3, 238:17 largely 159:2, 159:4, 198:20 last 34:5, 35:12, 71:11, 79:5, 79:7, 89:15, 94:16, 95:20, 98:5, 98:6, 98:11 late 12:13, 129:17 latent 126:6 later 44:2, 99:1, 104:12, 115:1, 200:1, 269:19 latest 15:11, 18:13 latter 99:3 laughing 220:1
J			
jacob 4:13 jake 14:7, 14:9 january 31:11, 39:15, 39:18, 57:14, 75:22, 79:18, 80:7, 92:7, 92:17, 99:12, 199:3 job 1:24 john 142:16 journal 160:14 journalist 85:9, 85:10, 85:13, 85:15, 85:16 june 19:2			
K			
karikó 89:13, 89:20, 93:6, 97:4, 130:14, 190:21, 191:13 katalin 89:13 keegan 1:26, 2:13, 277:2 keep 77:8, 103:21,			
		L	
		lab 26:17, 46:19,	

laundry 223:15, 240:6, 240:11 lawyers 162:4 lead 78:2, 79:15, 79:22, 80:17, 82:1, 82:5, 83:21, 198:18, 199:14, 203:3, 230:7, 245:21 leads 271:4 learn 238:5, 263:2, 263:3 learning 25:12 least 106:18, 195:7, 196:19, 224:4 lee 4:12 left 136:20 legal 124:10, 161:13, 168:8, 168:12, 181:2, 181:5, 181:9, 181:19, 183:6, 218:2, 218:5, 219:9, 219:13, 219:19, 228:3 legalese 214:2, 218:16 legend 111:12 legends 135:21 length 208:9 less 127:3, 180:6, 275:3 let's 12:9, 19:5,	23:8, 30:18, 37:7, 52:14, 56:21, 68:17, 72:8, 74:4, 79:3, 94:1, 101:7, 102:4, 103:21, 107:20, 122:18, 125:18, 131:22, 135:16, 137:17, 139:13, 153:1, 164:5, 175:2, 176:18, 186:6, 197:21, 204:7, 208:13, 211:2, 212:1, 232:3, 234:2, 235:10, 246:22, 254:8, 270:12 level 49:12, 49:20, 50:3, 50:5, 51:9, 52:11, 108:15, 108:17, 120:16, 137:17, 154:9, 154:12, 154:14, 154:16, 154:18, 154:22, 155:11, 155:15, 155:17, 155:19, 196:16, 227:18, 231:15, 255:1, 255:19, 256:13, 257:3, 257:8, 258:1, 265:19, 265:20 levels 121:3, 131:7, 131:11, 153:22, 192:8, 227:15, 232:10, 256:14, 257:1, 263:16, 270:15 leverage 271:12 licensed 22:22, 85:2, 118:19 light 230:5	likelihood 229:13 likely 19:16, 19:21, 27:20, 58:19, 59:8, 73:15, 84:18, 187:8, 253:12 likened 160:12 likewise 22:10, 47:6 limit 43:15 limitation 181:15, 209:16, 209:22, 210:10, 210:15, 211:14, 211:18 limited 224:11, 241:16 line 71:12, 109:15, 125:19, 132:14, 132:17, 136:3, 139:16, 144:19 linear 242:13, 242:20, 243:1 lines 23:9, 53:2, 58:3, 70:19, 80:21, 109:9, 109:16, 110:3, 112:19, 115:3, 199:16, 265:1 lingo 124:10 link 90:6, 207:9, 207:18, 207:22, 208:2, 208:6, 208:12 lion 47:13, 54:3, 67:21 lions 52:19	lipid-based 55:2, 225:10 lipids 139:15, 156:21, 157:3, 224:11, 224:12, 224:16, 224:18 lipo 88:3 lipofectin 34:4, 34:7, 34:8 liposomes 88:3, 192:12, 194:3, 223:5 list 176:3, 176:16, 179:8, 223:4, 223:15, 223:16, 224:12, 240:6, 240:8, 240:11, 245:7, 250:22 listed 18:19, 176:15, 223:10, 223:22, 226:7, 250:16, 250:18 listing 225:20 literature 15:7, 15:9, 15:22, 16:19, 36:8, 36:11, 36:13, 40:19, 41:3, 42:9, 42:10, 42:11, 42:14, 42:16, 42:18, 42:21, 43:2, 43:10, 43:14, 44:18, 54:7, 54:11, 67:3, 69:16, 69:18, 69:21, 121:2, 121:9, 121:12, 175:17, 175:18, 261:15, 262:18 little 29:17, 51:16,
---	---	--	--

53:12, 75:4, 80:4, 81:6, 110:20, 123:18, 147:21, 158:4, 158:6, 163:1, 170:20, 182:20, 229:18, 233:16, 237:2 liu 3:14 live 195:19, 196:2 llp 2:4, 3:7, 3:15, 4:6, 277:18 lnp 113:1, 117:14, 118:5, 136:4, 233:1, 233:17, 234:3, 234:6, 255:19, 262:12, 263:9, 263:11, 263:17, 264:13, 264:18 lnp-facilitated 111:17 lnps 104:11, 104:17, 105:10, 107:11, 111:19, 112:21, 113:11, 115:19 load 257:10 loads 256:8 located 47:8 long 17:8, 22:7, 50:9, 76:15, 79:8, 95:20, 134:2, 159:6, 159:18, 179:2, 179:10, 180:11, 223:16 look 19:5, 30:6, 37:7, 43:9,	45:1, 54:10, 55:8, 55:14, 68:5, 68:17, 80:20, 82:9, 94:1, 108:8, 109:9, 121:2, 121:5, 121:12, 122:18, 133:7, 134:16, 135:14, 135:20, 136:1, 141:6, 147:4, 148:15, 149:1, 149:12, 163:1, 170:10, 176:5, 181:12, 211:2, 219:16, 225:4, 244:13, 251:6, 252:2, 253:14, 265:15, 269:5, 273:7, 274:20, 275:7 looked 15:14, 43:14, 44:4, 44:22, 55:7, 55:15, 136:16, 137:2, 190:21, 197:12, 264:8, 267:16, 274:11 looking 25:10, 32:15, 32:16, 62:8, 91:21, 104:19, 105:3, 111:12, 111:13, 114:19, 115:2, 117:2, 117:15, 133:6, 135:10, 137:6, 143:10, 147:7, 164:13, 215:17, 215:20, 223:3, 236:21, 244:1, 244:16, 265:14 looks 18:7, 18:15, 21:4, 150:4, 159:11 loss 130:17	lost 204:10 lot 43:17, 43:20, 63:2, 65:3, 77:10, 81:1, 85:3, 85:4, 86:2, 86:8, 86:11, 86:20, 106:3, 125:12, 125:16, 126:11, 134:4, 174:21, 175:15, 177:13, 177:14, 177:17, 177:21, 178:18, 195:13, 195:15, 195:17, 196:7, 201:12, 202:5, 203:4, 203:7, 205:14, 206:3, 206:5, 222:14, 229:9, 258:18 low 229:5 low-bar 197:13 lower 120:6, 120:22, 259:7 luciferase 227:10, 227:11 lunch 157:8, 157:10, 158:5 lynne 7:13 <hr/> M <hr/> machinery 128:5, 130:4, 131:1 made 44:6, 44:13, 96:1, 96:3, 96:20, 99:14, 107:4, 168:18, 170:11, 171:10, 172:3, 219:12,	251:17, 272:17 magnitudes 273:4 main 3:16, 88:10, 124:2, 142:17 maintained 112:20 major 200:2, 200:11, 200:17, 201:21 majority 42:14, 43:22, 44:17, 129:5, 144:15, 193:5, 194:20, 274:14 make 18:12, 33:8, 36:17, 67:13, 76:11, 77:15, 83:8, 83:9, 86:11, 94:22, 95:21, 97:5, 97:8, 97:21, 98:2, 98:7, 99:21, 100:17, 145:12, 146:17, 160:10, 162:22, 172:9, 172:20, 175:2, 175:4, 185:9, 191:5, 203:7, 210:20, 214:11, 214:22, 215:22, 234:5 makes 19:9, 77:5, 77:6, 101:5, 138:17, 138:19, 138:21, 146:21, 157:9, 231:22 making 42:7, 45:2, 54:4, 67:4, 78:8, 78:20, 96:9, 214:3 manner 164:17 manufacture 22:7
---	--	---	---

manuscript 36:1, 36:5, 90:5, 160:2, 160:10, 160:14, 160:20, 172:15, 173:10, 191:2, 238:2, 238:13, 238:20, 238:21	match 20:11, 20:16, 22:6, 22:13, 23:6, 150:2	264:19, 266:8, 267:1, 267:6, 267:13, 272:13, 272:19, 273:19, 276:1, 276:4	mechanisms 252:17, 252:18, 252:20, 253:1
manuscripts 160:21, 170:16	matched 110:21	mcherry 227:4	mediated 59:10, 60:2, 60:11, 61:7, 61:18, 72:15, 73:11, 73:21, 73:22
many 61:22, 133:20, 133:22, 156:20, 173:20, 173:22, 174:3, 178:8, 178:10, 179:12, 179:16, 180:21, 223:9, 223:11, 225:21, 250:16	matches 22:17	mean 19:20, 20:5, 20:14, 28:9, 28:11, 33:3, 35:18, 60:10, 66:19, 69:10, 76:22, 87:8, 95:12, 115:15, 118:20, 123:19, 124:2, 133:14, 141:19, 165:7, 165:8, 167:7, 172:18, 221:20, 228:17, 229:8, 238:22, 245:18, 245:20	mediates 58:4, 58:11
march 70:8, 71:4	matching 148:17	materials 8:16, 14:2, 14:21, 14:22, 175:18, 176:3, 176:9, 176:16	medical 227:20, 264:11
marked 6:1, 11:21, 18:2, 18:4, 18:5, 35:1, 35:4, 69:21, 70:2, 75:7, 88:13, 88:16, 102:7, 102:10, 122:16, 142:1, 142:5, 158:9, 198:8, 208:20, 209:1, 239:4, 239:6, 257:15	material 47:9, 175:14, 175:21, 175:22, 176:2, 179:13	matter 43:20, 277:27	medicine 251:21
marker 227:21, 228:14	max 265:6	maximize 150:11, 265:7	meet 14:5, 17:4, 17:8, 185:2, 185:4
markers 227:15, 227:16, 227:19, 228:5	maybe 30:7, 30:10, 60:22, 113:9, 115:10, 121:21, 143:21, 152:9, 161:8, 163:10, 167:14, 180:3, 213:4, 221:13, 221:14, 224:1, 230:13, 231:1, 263:3	meaning 74:17	meetings 179:17, 180:10, 180:12
marriage 277:24	mays-williams 3:5, 5:4, 7:8, 75:3, 75:10, 82:18, 99:19, 157:7, 158:2, 172:8, 177:6, 208:17, 208:19, 221:6, 221:8, 247:2, 254:5, 255:9, 255:11, 255:22, 258:3, 263:18, 264:3,	means 20:1, 20:15, 34:4, 35:19, 88:2, 119:2, 162:17, 167:8, 185:11, 195:19	meets 185:17, 185:19
mascola 142:16		meant 41:19, 41:20, 51:20, 60:13, 132:3, 243:8	member 184:18
massachusetts 1:20, 2:6, 2:15, 4:8, 277:4, 277:19, 277:35		measurable 232:4	membrane 40:3, 45:14, 116:7
		measure 231:21, 232:6, 232:9	memorialized 99:11
		measured 227:1	mention 109:21, 213:7
		measures 227:1	mentioned 16:3, 16:7, 17:1, 24:13, 26:21, 33:21, 44:12, 46:12, 48:18, 52:16, 67:17, 82:6, 107:17, 166:12, 168:22, 172:13, 173:8, 175:19, 178:7, 194:13, 235:5, 238:14, 261:9, 265:2,
		meat 123:22	
		mechanism 144:16, 187:8	

269:17 mentioning 18:21 merit 2:13, 277:2 mers 22:22, 23:1, 23:4, 40:14, 41:12, 44:2, 63:2, 126:8, 126:17, 134:1, 134:9, 141:17, 143:19, 150:17, 151:5, 246:15, 255:20, 256:5, 257:18 mers)-cov 73:9 mers-cov 5:22, 22:19, 42:13, 72:14, 73:17, 132:11, 132:19, 133:1, 133:3, 133:21, 134:9, 134:11, 141:9, 141:11, 141:15, 141:21, 142:21, 143:5, 143:9, 145:18, 146:1, 146:10, 146:11, 257:17 messenger 28:21, 128:4, 130:2, 153:6, 188:4, 263:4 met 13:9, 13:12, 14:4, 14:6, 14:15, 17:1, 17:5, 17:6, 17:13, 17:18 method 19:14, 48:7, 153:5, 153:18, 153:20 methodology 228:10 methods 131:4, 192:14,	194:5, 218:18, 269:2 methyl 117:1 meuth 3:6 mice 5:15, 23:14, 33:16, 35:9, 50:4, 50:7, 72:13, 73:8, 73:18, 118:7, 132:6, 132:19, 145:18, 147:11, 147:14, 148:4, 148:12, 148:22, 150:1, 197:1, 197:4, 197:6, 197:13, 270:14 michael 3:14 michelle 1:26, 2:12, 277:2 microbiology 7:22, 18:8 microspheres 223:5, 223:20, 223:21 mid 12:13, 186:10 middle 73:9, 142:20, 143:4, 143:12, 237:2 might 19:10, 25:9, 30:5, 113:16, 117:19, 121:5, 121:12, 121:21, 144:3, 203:22, 251:5, 263:4 mind 16:2, 77:8, 82:10, 103:21, 144:2, 211:8, 212:5, 222:3, 248:20	minimizing 265:8 minus 159:7, 230:4 minute 85:7, 111:5, 176:21, 235:11, 255:12 minutes 180:16 mischaracterize 170:5 mischaracterizes 156:6, 170:4, 171:17, 172:1, 172:10, 178:6, 249:15, 249:16 missed 143:2, 231:1 missing 96:19, 187:21 misspoke 59:19, 132:3 modalities 24:8, 25:8, 25:9, 66:8, 66:16, 74:11, 248:13, 248:17, 266:6, 266:10, 269:3, 273:17 modality 28:14, 28:15, 74:16, 120:21, 258:20 model 54:19, 73:17, 84:16, 257:2, 257:10 models 29:16, 63:9, 197:2, 249:10, 253:17, 274:12 moderna 4:13, 11:16, 12:8, 12:22, 104:13, 251:8, 253:16 modernatx 1:8, 4:3,	254:11, 277:13 modification 90:2, 94:18 modified 28:19, 95:7, 96:3, 99:8, 190:5, 190:13, 191:4, 191:7, 224:3, 225:17, 226:3, 236:14 modifying 86:10, 203:6 modulated 190:5, 190:13 mol 136:8, 136:9, 136:10, 136:12, 138:1, 138:2, 140:1, 140:3, 153:13, 153:14, 153:15 molar 226:1, 226:4 molecular 270:21 molecule 78:7, 78:15, 78:19 molecules 191:19, 236:15, 240:13 moment 23:8, 26:21, 52:15, 53:3, 63:22, 64:5, 68:4, 68:18, 109:13, 139:14, 153:2, 176:5, 186:7, 212:2, 245:15, 269:8, 275:18 monoclonal 73:2 monoclonic 217:7, 217:8 months 57:4 moore 4:13
---	--	--	--

<p>more 30:19, 44:2, 44:20, 48:15, 56:11, 65:14, 66:12, 80:1, 80:14, 80:19, 81:1, 81:21, 82:14, 83:15, 86:11, 87:7, 120:4, 129:10, 129:13, 129:14, 133:10, 137:16, 146:20, 152:18, 158:6, 160:18, 161:12, 174:21, 179:19, 179:20, 179:21, 179:22, 180:1, 180:7, 185:10, 188:8, 188:13, 189:21, 191:5, 191:8, 191:11, 192:14, 195:15, 195:17, 201:15, 203:7, 210:17, 225:13, 228:11, 229:3, 242:12, 242:16, 251:9, 252:15, 253:9, 253:12, 253:18, 259:11, 260:14, 275:6</p> <p>morning 7:9, 7:10, 15:14, 190:22, 202:4, 266:3</p> <p>mortality 143:22</p> <p>most 18:16, 20:9, 45:10, 59:11, 60:4, 60:17, 62:11, 63:3, 68:7, 71:15, 97:14, 127:1, 129:3, 144:16, 171:9, 171:10, 172:2, 172:3, 178:9, 180:17,</p>	<p>187:8, 197:2, 258:11, 262:2, 274:12</p> <p>mostly 54:13, 60:21, 65:2, 231:13</p> <p>motivated 246:8</p> <p>motivation 244:18, 245:16, 245:18</p> <p>mouse 39:10, 46:11, 73:17, 256:3</p> <p>move 47:21, 48:19, 74:4, 135:16, 231:22</p> <p>moved 129:4</p> <p>mrna's 97:20</p> <p>mrna) 128:4, 130:3</p> <p>mrnas 94:5</p> <p>much 9:4, 61:1, 65:20, 67:17, 81:9, 129:4, 129:13, 160:17, 169:5, 180:9, 191:3, 197:19, 207:17, 259:7, 259:11, 276:6, 276:7</p> <p>mucosal 26:20, 273:9</p> <p>multiple 120:1, 120:7, 124:9, 133:8, 160:3, 160:6, 170:15, 187:17, 188:1, 194:2, 201:14, 204:4, 214:9, 222:10, 248:16</p> <p>muscle 39:9, 52:5,</p>	<p>114:17, 115:14</p> <p>must 182:3, 207:9</p> <p>myself 59:18, 89:2, 124:9, 214:9</p> <hr/> <p>N</p> <hr/> <p>nab 144:11, 147:11, 147:17</p> <p>naked 34:3, 54:21, 192:6, 192:15, 196:14</p> <p>name 7:11, 7:13, 12:15</p> <p>names 14:14</p> <p>nanocarriers 88:3</p> <p>nanolipid 47:6</p> <p>nanoparticle 54:1, 54:5, 54:14, 67:21, 88:8, 103:14, 108:4, 116:14, 116:17, 135:18, 136:4, 136:18, 137:4, 137:21, 138:22, 139:5, 140:17, 153:9, 153:12, 156:15, 197:18, 223:1, 224:3, 224:7, 224:10, 224:17, 224:21, 225:3, 225:6, 225:12, 248:2, 248:8</p> <p>nanoparticle-bas- ed 55:9, 55:21, 56:7</p> <p>nanoparticles 52:19, 104:17, 105:9, 105:13,</p>	<p>106:1, 106:6, 106:11, 106:14, 106:17, 106:20, 108:9, 108:12, 108:18, 109:5, 110:10, 112:8, 112:12, 115:13, 115:21, 138:18, 192:13, 194:3, 197:17, 223:12, 223:18, 223:21, 224:15, 224:16, 225:15</p> <p>narrow 19:12</p> <p>national 8:1, 19:1</p> <p>native 128:6</p> <p>natural 93:17, 97:5</p> <p>naturally 116:4</p> <p>nature 94:9, 94:11, 163:11, 169:7, 265:22</p> <p>nearly 128:6, 130:4, 131:2</p> <p>necessarily 20:22, 49:5, 50:12, 99:21, 152:10, 152:19, 196:16, 201:10, 217:11, 228:17, 229:8, 230:7, 238:22, 246:16, 252:22, 265:20, 265:21</p> <p>necessary 53:13, 219:6</p> <p>need 9:16, 18:17, 18:20, 23:6, 57:19, 58:2, 83:12, 120:15, 126:6, 126:10,</p>
---	--	--	--

143:6, 143:14, 173:18, 192:9, 192:11, 208:5, 230:8, 254:7, 256:14, 271:17, 271:18, 271:19 needed 53:8, 85:18, 131:7, 131:9, 178:22, 179:3, 180:14 needs 18:15, 145:5, 230:8, 236:7 negative 34:13 neutral 109:2, 153:14, 156:17, 157:2 neutralizing 5:13, 35:9, 40:16, 40:20, 41:4, 41:17, 41:22, 42:2, 49:12, 49:21, 50:6, 51:9, 52:11, 59:10, 59:15, 60:3, 60:8, 60:11, 61:8, 61:18, 61:21, 62:3, 68:11, 72:12, 73:7, 118:8, 118:21, 119:5, 144:10, 144:14, 144:20, 145:1, 145:6, 147:17, 148:8, 149:12, 149:14, 149:15, 150:11, 150:15, 152:2, 152:6, 152:8, 155:9, 155:11, 155:15, 155:17, 155:20, 156:2, 156:3, 187:8, 196:20, 197:12, 256:6, 257:8, 260:14,	261:4, 270:16, 272:1 neutralizing-ant- ibody 70:13, 70:22, 71:7 never 8:6, 38:1, 189:14, 269:15 new 3:9, 20:1, 20:5, 20:12, 22:6, 22:11, 32:11, 75:12, 86:9, 101:13, 101:20, 101:22, 102:19, 103:11, 103:19, 107:5, 127:2, 132:6, 197:8, 201:4, 201:18, 202:6, 203:5 next 19:17, 19:22, 32:21, 71:11, 74:7, 77:3, 79:3, 84:17, 84:18, 114:15, 114:22, 126:17, 199:22, 205:17, 207:5, 230:6, 231:22, 240:21 night 17:6 nobody 127:10 nods 10:3 non-cationic 136:6, 136:9 non-human 145:18 non-self 66:19 non-self-amplify- ing 66:8, 66:16 nonamplifying 121:4, 121:9	noncationic 139:22, 140:10 none 8:22 nonhuman 5:15, 23:14, 35:10, 39:10, 250:20 nonimmunogenetic 89:8 nonintegrating 189:5 nonlimiting 236:14 nonreplicating 114:6 nonself-replicat- ing 119:18 nontraditional 187:12, 187:15, 188:22 nonviral 102:13 norbert 177:11, 198:13 normal 189:22 northeast 7:15 notably 86:2, 86:8, 202:6, 203:4 notary 2:13, 7:4, 277:1, 277:3, 277:34 note 117:12, 219:22 noted 79:17, 101:13, 246:15, 247:15 notes 8:21 nothing 99:7, 184:13 notice 2:12, 80:14	novel 21:15, 21:18, 22:1, 128:7 novelty 21:22 november 89:17, 96:1 nuclease 189:13, 189:14 nucleic 24:1, 24:5, 24:7, 32:7, 32:10, 32:14, 34:9, 40:5, 43:21, 44:5, 44:11, 44:19, 45:1, 48:12, 48:22, 49:3, 52:1, 53:6, 53:9, 53:14, 53:15, 53:19, 54:2, 54:6, 54:20, 55:2, 56:14, 57:17, 74:6, 74:10, 74:18, 74:20, 77:1, 77:3, 77:4, 84:11, 84:22, 85:2, 105:18, 105:19, 106:2, 106:4, 141:19, 185:16, 185:21, 186:1, 186:4, 194:18, 194:22, 195:3, 196:6, 196:8, 208:3, 213:2, 213:3, 236:15, 253:8, 266:5, 266:17, 268:9, 268:12, 268:15, 268:19, 269:6, 269:14, 269:15, 273:17 nucleoside 94:18, 96:2 nucleosides 95:7, 190:5,
---	--	--	---

190:13, 191:4 nucleotide 133:8, 133:20, 133:22, 134:6 nucleus 83:8, 83:18 number 11:3, 11:9, 26:9, 45:22, 47:2, 69:4, 75:12, 81:17, 82:8, 93:13, 98:12, 110:18, 123:2, 137:6, 156:15, 157:2, 158:11, 177:3, 245:22, 246:1, 261:18	255:12, 255:13, 255:22, 263:18, 264:3, 264:19, 266:8, 267:1, 267:3, 267:6, 267:13, 272:13, 272:19 objection 41:6, 44:15, 49:22, 62:9, 86:5, 91:4, 91:22, 96:5, 99:16, 99:17, 151:9, 155:1, 170:4, 171:17, 172:1, 172:10, 190:9, 192:1, 206:21, 209:18, 210:3, 210:13, 212:21, 219:8, 220:10, 220:21, 221:4, 222:8, 242:6, 249:4, 249:15, 255:9, 258:3, 273:19 objections 9:12, 92:12, 92:18, 172:9, 190:16, 218:10, 224:22, 230:1, 231:3, 231:7, 231:17 objective 27:4, 96:21, 106:10, 150:12, 234:19, 264:22 objectives 96:14 obligated 9:10 observed 248:11, 248:15, 259:18 obtained 132:22, 141:9 obvious 243:12, 243:19, 244:4	obviously 175:14, 196:5 occasional 143:19 occur 23:16 occurred 40:14, 41:13, 277:17 occurring 107:16 october 32:3, 32:5, 34:11, 34:18, 58:18, 59:7, 62:11, 62:18, 123:3, 123:15, 130:12, 131:19, 193:10, 193:18, 205:22, 243:13 offer 188:20, 214:12, 214:18, 215:2, 215:7, 215:10, 215:18 offered 182:14, 182:16, 182:18, 182:21, 183:2, 183:5, 215:13, 216:5, 216:8, 218:11 offers 216:10, 216:19 office 1:1 offices 2:2, 277:17 often 28:18, 144:19 oh 103:9, 104:22, 138:9, 147:7, 199:12, 240:6 okay 8:7, 9:6, 9:13, 9:20, 9:21, 10:4, 10:5, 10:9, 10:10,	10:13, 18:14, 49:8, 52:14, 53:4, 56:21, 64:12, 67:6, 68:3, 68:17, 70:11, 72:8, 75:11, 76:14, 79:4, 87:4, 87:5, 87:21, 88:12, 88:19, 89:5, 102:4, 105:6, 106:17, 107:20, 109:11, 109:20, 112:17, 115:2, 117:11, 117:21, 119:13, 121:1, 122:4, 122:18, 124:16, 137:18, 138:9, 139:13, 141:6, 143:13, 151:13, 158:3, 159:5, 174:10, 175:1, 175:11, 183:6, 194:12, 198:7, 199:12, 199:18, 202:15, 202:18, 204:7, 204:14, 211:7, 211:21, 212:1, 212:8, 216:4, 233:14, 234:2, 234:4, 235:10, 247:5, 250:15, 254:3, 254:7, 254:14, 254:15, 255:14, 257:19, 263:6, 266:2 once 10:7, 50:21, 51:7, 78:6, 78:14, 83:16, 95:15, 116:2, 126:13, 147:16, 148:4, 162:21, 188:4, 190:2, 193:6, 274:10 one 9:17, 15:16,
---	---	---	--

16:6, 17:13, 22:16, 26:14, 27:12, 28:20, 33:18, 34:5, 45:9, 50:15, 50:17, 56:2, 59:18, 68:22, 69:11, 69:12, 71:15, 88:11, 92:19, 93:14, 98:14, 102:19, 104:9, 104:22, 109:13, 114:13, 120:21, 121:20, 131:16, 135:4, 136:17, 137:3, 137:20, 138:1, 145:3, 148:11, 152:10, 156:10, 158:12, 159:18, 170:17, 170:20, 180:17, 185:10, 195:8, 197:2, 198:5, 201:2, 202:12, 204:11, 204:12, 204:13, 222:5, 222:13, 223:8, 223:9, 223:18, 224:4, 225:2, 225:11, 225:15, 226:7, 227:16, 230:15, 230:17, 231:5, 233:2, 233:18, 245:8, 248:9, 249:6, 250:13, 250:16, 251:9, 253:17, 256:13, 256:20, 257:14, 258:11, 260:7, 261:2, 261:3, 262:21, 266:10, 266:17, 267:10, 268:14, 271:12, 272:3, 274:3, 274:8, 275:6, 275:18 ones 64:22, 65:5,	65:19, 66:1, 85:18, 244:9, 250:22 ongoing 23:18, 266:14 only 34:16, 43:9, 48:8, 62:1, 74:12, 83:12, 97:15, 121:18, 121:20, 132:8, 145:3, 156:3, 165:9, 170:19, 181:14, 183:21, 186:12, 211:13, 218:22, 237:20, 245:8, 256:22, 267:10, 272:11, 273:4 open 153:7 opine 157:1, 157:4 opinion 182:14, 182:16, 182:18, 182:21, 183:2, 183:5, 214:12, 214:18, 215:2, 215:7, 215:10, 215:13, 215:19, 216:5, 216:8, 216:9, 216:13, 216:16, 218:12, 218:15, 218:17, 235:12, 264:21 opinions 171:1, 171:4, 171:14, 171:21, 172:11, 172:21, 173:6, 216:2, 239:11 opportunity 82:9, 255:12, 272:7 opposing 96:13, 96:21 opposite 98:1, 235:7	optimal 120:19, 122:3, 207:9, 207:18, 207:22, 208:2, 208:6 optimization 204:16 optimize 144:10, 228:7, 265:4, 265:10 optimized 46:19 option 226:3, 226:7 options 139:19, 245:12 order 53:17, 53:18 ordinary 130:20, 168:15, 183:8, 243:13, 257:4, 262:10 organic 170:14 organism 216:22, 217:6, 220:20, 221:19, 222:6, 222:11 organisms 217:13 original 123:8, 128:14, 169:12, 172:16, 173:11, 173:15 originally 163:2, 163:6, 178:19 other 14:21, 15:5, 15:19, 17:14, 18:20, 18:21, 21:11, 28:6, 28:22, 31:14, 39:20, 43:10, 44:5, 44:11, 45:1, 45:8, 46:10, 46:13, 46:19, 47:3,	48:22, 55:2, 55:7, 55:8, 62:15, 62:16, 63:11, 63:14, 66:7, 66:15, 67:20, 69:1, 81:14, 85:17, 88:6, 92:22, 93:1, 93:16, 107:19, 116:12, 116:19, 120:22, 121:16, 125:21, 128:7, 141:3, 141:21, 145:4, 145:5, 145:10, 158:12, 164:6, 175:3, 176:2, 178:1, 184:1, 188:21, 195:18, 216:11, 217:9, 217:14, 222:14, 225:21, 229:10, 233:3, 233:19, 234:1, 241:10, 248:13, 249:13, 249:19, 250:22, 253:6, 260:3, 265:4, 268:22, 272:4 others 45:12, 53:22, 55:14, 55:17, 66:1, 120:5, 178:3, 201:13, 249:7, 250:17, 250:18 otherwise 213:19, 277:26 out 13:16, 21:12, 22:15, 29:1, 31:22, 48:10, 55:10, 55:22, 65:20, 84:2, 85:7, 85:13, 100:1, 112:4, 121:19, 121:20, 131:4, 136:1,
--	---	--	--

136:20, 138:5, 154:7, 166:8, 166:21, 169:14, 178:20, 180:3, 193:21, 210:5, 228:14, 249:7, 254:20, 257:13, 260:1, 271:13, 272:9, 275:10, 275:14 outbreak 40:14, 41:12, 41:15, 42:12, 126:14, 126:18, 127:3 outbreaks 41:21, 42:13, 126:8, 143:20 outcome 275:12, 275:16, 277:27 outer 186:14, 186:19, 186:21, 187:2, 187:4, 187:6 outperform 80:15 outside 88:7, 94:14, 115:9, 124:14, 125:7, 128:9, 142:7, 156:22, 218:5, 228:3, 229:16, 229:18, 229:21, 230:20, 231:7, 232:14, 232:18, 233:5, 233:21, 234:8 over 9:7, 10:8, 75:4, 79:22, 80:18, 82:14, 82:22, 83:4, 83:21, 123:11, 158:5, 164:6, 171:8, 171:18, 175:3, 177:16, 178:15, 200:1,	200:16, 200:22, 201:20, 203:18, 229:20 overall 196:6 owing 198:20 own 44:7, 44:13, 45:3, 72:2, 121:7, 161:7, 165:17, 170:19, 171:5, 177:17, 178:15, 179:6, 251:18 owner 1:9, 4:3, 11:15, 254:11 ownership 171:8, 171:18 <hr/> P <hr/> page 5:3, 5:9, 18:10, 19:3, 23:8, 23:9, 23:22, 30:18, 31:22, 56:22, 71:11, 72:11, 79:3, 79:5, 107:20, 107:21, 112:18, 117:21, 117:22, 122:22, 138:7, 147:5, 147:6, 147:7, 170:7, 170:22, 174:7, 174:8, 175:5, 176:6, 181:3, 183:6, 199:5, 199:8, 204:8, 204:14, 205:17, 210:20, 211:10, 212:1, 215:21, 222:20, 239:21, 239:22, 240:1, 240:9, 240:22, 241:12, 244:15, 247:4,	249:20, 250:8 pages 1:25, 159:6, 159:13, 159:18 paiv 250:11 pandemic 19:17, 19:22, 20:2, 20:5, 22:4, 22:6, 22:9, 22:20, 30:21, 37:4, 57:7, 84:13, 84:17, 84:18, 85:6, 126:8, 144:3 panel 151:22 paper 36:18, 39:5, 46:16, 55:6, 64:9, 64:16, 67:16, 97:3, 97:22, 113:13, 113:14, 150:10, 152:14, 201:16, 251:21, 253:10, 258:7 papers 43:4, 84:1, 196:14, 244:2, 267:17 par 259:5 paragraph 71:12, 74:7, 79:6, 79:7, 101:18, 101:19, 102:9, 115:4, 165:9, 169:14, 182:1, 184:2, 184:17, 186:6, 186:8, 186:10, 194:11, 197:21, 198:15, 208:13, 210:6, 211:6, 212:2, 212:3, 220:18, 221:2,	221:10, 221:15, 223:7, 224:1, 225:4, 236:13, 236:22, 237:3, 246:19, 247:7, 247:9 paragraphs 159:10, 159:15, 220:3, 222:20, 223:2 parallel 174:5, 202:20 parallels 202:18 parasite 240:19, 241:5 pardi 177:11, 198:12, 199:2, 199:6, 200:8, 201:20, 203:11, 204:7, 207:5 pardon 115:1 parentheses 238:4, 238:14, 238:16 park 3:8 part 25:22, 52:10, 143:10, 184:19, 184:22, 185:5, 185:8, 201:18, 268:14 particular 41:21, 46:11, 47:12, 48:1, 49:3, 50:3, 54:14, 55:5, 63:19, 67:16, 67:19, 82:7, 90:1, 92:20, 93:21, 97:3, 97:22, 99:8, 100:13, 103:22, 104:4, 104:6, 106:5, 107:10,
--	---	---	--

107:22, 111:4, 113:4, 116:1, 119:3, 129:20, 161:10, 163:1, 189:21, 191:2, 208:3, 228:19, 229:11, 231:10, 233:10, 254:22, 256:2, 256:16, 262:4, 262:19, 268:3, 272:16, 275:7 particularly 42:11, 81:2, 81:16, 118:16, 119:4, 126:19, 130:13, 206:4 parties 277:23, 277:25 partnered 84:9 parts 70:12, 70:21, 71:6, 160:5, 170:8, 176:12 party 178:1, 277:12 pass 254:5, 275:22 passive 44:22, 73:13 passively 73:16 past 28:19, 200:1, 200:16, 201:20 patent 1:1, 1:3, 1:9, 1:12, 1:15, 4:3, 10:18, 11:3, 11:6, 11:9, 11:12, 11:15, 25:22, 122:6, 122:7, 122:13, 122:14, 122:19, 123:5, 123:9, 123:14, 123:16, 124:6, 124:7,	125:3, 125:18, 127:11, 127:12, 128:12, 129:1, 130:1, 131:13, 131:19, 132:13, 140:16, 153:1, 153:3, 153:4, 158:22, 159:6, 159:10, 159:13, 159:18, 162:1, 164:11, 164:16, 164:19, 167:3, 168:3, 174:4, 175:8, 175:9, 175:12, 175:20, 180:20, 181:2, 181:13, 182:8, 209:21, 210:9, 210:14, 211:12, 211:17, 212:17, 213:21, 214:6, 214:7, 214:8, 214:11, 214:14, 214:19, 215:3, 215:12, 218:4, 235:18, 235:19, 236:1, 236:5, 237:6, 237:10, 237:11, 238:1, 243:11, 244:20, 254:11, 254:17, 255:15, 255:16, 255:18, 256:2, 256:16 patenting 256:20 patents 12:22, 122:6, 122:9, 123:17, 123:22, 124:9, 124:18, 175:15, 214:3, 214:9, 215:15, 222:4, 235:13, 244:2, 245:14 pathogen 50:17, 50:18, 186:13, 187:1,	189:2, 245:8, 275:16 pathogenic 98:17 pathogens 240:7, 240:8, 245:7 pathology 44:21 pathway 188:8, 188:14 patients 178:12 pattern 271:3 paul 3:7 payload 106:2, 106:8 peg 136:6, 136:10, 140:3, 140:10, 225:7, 225:18, 226:2, 226:6 peg-domg 136:10, 138:2, 140:3 peg-modified 153:15, 156:18 pegylated 112:14, 112:15, 117:9 pending 9:18, 221:4, 221:6 people 10:7, 17:14, 38:3, 61:2, 126:21, 143:21, 160:3, 161:12, 162:21, 196:5, 197:8, 201:17, 268:14, 269:1, 269:12, 274:14 people's 126:16, 144:2 peptide 212:14, 243:1,	243:2 percent 108:20, 109:7, 109:22, 110:12, 112:9, 112:10, 112:14, 112:16, 117:3, 117:5, 117:7, 117:9 perform 25:13, 27:20, 28:5, 28:10 performance 205:13 performed 252:6 performing 80:22 perhaps 96:18 period 82:11 peritonitis 250:1 person 130:20, 137:10, 168:15, 183:8, 231:20, 243:12, 257:4, 262:9, 263:10 person's 78:8, 78:19 personally 162:10, 162:12, 162:15, 162:17, 164:22, 165:2, 165:4, 165:7, 165:15 petitioner 1:6, 3:3, 3:12, 7:7 petitioners 244:17, 254:22, 257:15, 257:21, 263:15, 264:1, 266:21 pfizer 1:5, 3:4, 3:12, 7:7, 13:3,
--	--	--	--

13:20, 182:11, 209:9, 243:10, 243:18, 244:5, 251:8 pfizer's 253:16 ph 1:19, 2:1, 5:3, 7:2, 185:12, 277:5, 277:17 phenomenon 149:18 phrase 102:22 phrases 169:6 physical 194:4 physically 166:12, 166:15, 166:17, 166:20, 167:1 physiologically 94:5 pick 85:13 pickering 2:4, 4:6, 277:18 picky 161:19 picture 66:13, 100:7, 101:17, 115:16, 115:17, 140:9 piece 69:16, 69:20 pieces 244:1 pinpoint 180:9 place 47:17, 48:8, 67:18, 101:16, 204:5, 232:21 placed 89:6 platform 22:2, 28:13,	28:15, 28:20, 28:21, 29:3, 29:4, 30:4, 30:10, 47:16, 47:19, 48:5, 49:4, 50:11, 67:17, 68:1, 120:5, 189:5, 227:17, 232:7, 232:12, 232:17, 235:2, 239:19, 248:10, 249:2, 249:7, 254:2, 256:21, 271:20, 275:17 platforms 25:4, 25:12, 26:5, 27:11, 27:20, 28:5, 28:10, 29:13, 33:11, 46:9, 46:12, 46:18, 197:9, 249:12, 249:13, 249:14, 258:6, 265:15, 270:6, 270:8, 271:7, 271:13, 272:7 play 71:6 plays 70:12, 70:21, 207:7, 207:15 please 7:11, 7:14, 10:12, 41:2, 177:8, 222:19, 239:21 plug 270:5 plus 230:4 point 24:18, 68:2, 81:4, 84:7, 96:12, 100:1, 127:3, 131:10, 137:21, 138:5,	156:2, 168:9, 169:14, 170:18, 172:17, 172:22, 173:11, 183:1, 183:3, 190:22, 194:9, 201:17, 210:4, 226:11, 236:12, 251:1, 253:21 pointed 85:7, 154:7, 249:9, 255:5 polar 96:13 poly(a) 207:7, 207:9, 207:11, 207:14, 207:19, 208:6, 208:9, 208:12 poly-a 135:6, 135:7, 135:8 polymerase 207:12 polynucleotide 132:20 polypeptide 212:14, 240:14, 241:2, 241:6, 241:9, 241:20, 241:21, 242:8, 242:10, 242:12, 242:16, 242:19, 243:2, 243:4, 243:9 popular 129:13, 258:11 population 19:12 portfolio 177:21, 177:22, 178:8, 178:14, 178:21, 179:7 portion 150:5, 161:8, 166:10, 171:4, 183:21, 185:22, 187:10, 203:8,	203:9, 203:11, 238:8 portions 164:22, 165:2, 165:4, 165:14, 165:18, 166:7, 171:10, 171:21, 172:2, 172:11, 173:5, 184:1 posa 78:13, 78:17, 121:2, 121:8, 121:12, 131:3, 183:12, 184:3, 184:8, 184:11, 184:12, 184:18, 184:20, 184:22, 185:18, 185:22, 213:9, 219:15, 219:16, 220:13, 234:5, 234:22, 235:6, 237:22, 243:20, 244:4, 244:13, 244:17, 245:3, 245:10, 246:2, 246:6, 246:7, 246:11, 246:16, 262:17, 262:18, 265:14 posa's 248:20 pose 189:20 positive 34:17 possible 10:6, 152:6, 225:21 possibly 73:21 postpone 13:11 potential 83:15, 94:6, 96:9, 96:11, 130:7, 187:4, 208:2, 212:12, 251:4, 251:14,
---	---	--	---

251:16, 252:18, 253:22, 261:6 potentially 21:13, 80:15, 252:5, 259:20, 260:4, 262:6, 271:8, 271:12 practice 220:13 precise 20:16, 54:9, 76:3, 106:16, 121:7, 245:13 precisely 23:11, 80:19, 168:6, 173:14, 173:22, 228:11 preclinical 251:6, 253:15, 253:16 predict 19:10, 19:14, 21:5, 50:12, 265:20 prediction 229:2, 229:3 predictive 228:21, 266:18 predominant 196:1 predominantly 158:20 preexisting 23:1 preliminary 50:8, 54:8, 54:16 premarked 122:13, 122:14 preparation 14:2, 15:3, 16:21, 122:10, 174:21 prepare 13:22, 17:2 prepared 144:4, 174:5, 174:6	preparing 160:13, 160:21, 173:20, 174:4, 175:1 present 4:11, 94:7, 236:15, 268:18 presented 84:7, 125:1, 142:12, 274:4 presenting 89:3, 269:1 presently 13:2 presents 30:17 pretty 65:20, 67:17, 129:3, 161:20, 207:17, 213:1, 234:12, 251:1, 251:12, 252:17, 258:16 prevalent 143:20 prevent 144:18 preventing 19:17, 19:22, 21:1, 21:7 previous 66:3, 66:7, 66:15, 67:9, 72:11, 73:6, 111:4, 259:17 previously 6:1, 44:17, 47:10, 70:2, 73:16, 88:13, 102:10, 122:16, 198:8, 209:1, 220:22, 221:5, 239:4, 239:7, 239:8 primarily 24:1, 26:15, 65:21, 121:8, 226:20, 228:6,	234:18, 242:20, 244:22, 265:7, 267:16, 267:17 primary 32:22, 88:1, 90:4, 160:7, 160:9, 234:19, 274:8 primate 8:1, 19:1, 39:10 primates 5:15, 23:14, 35:10, 145:18, 250:20 prime 149:8, 149:16, 151:19, 258:14, 258:18, 259:4 primed 147:15, 148:4, 148:12, 149:2 priming 196:3, 262:6 primings 259:1 principal 35:19, 35:21, 160:8, 160:22 principle 46:2, 48:11 printout 18:10 prior 45:21, 80:7, 80:16, 138:12, 140:8, 158:5, 181:16, 194:19, 203:13, 209:15, 209:17, 209:21, 210:1, 210:11, 210:16, 211:15, 211:19, 214:5, 214:13, 214:19, 215:3, 217:1, 217:20, 246:15, 252:3, 252:8, 259:19	priority 123:2, 123:5, 123:13, 129:20, 131:18, 158:19 probably 33:18, 76:13, 80:10, 80:13, 81:9, 88:10, 124:11, 160:16, 169:5, 170:8, 170:10, 195:22 problem 87:6, 87:19, 87:21, 89:21, 90:17, 91:2, 91:13, 92:5, 92:15, 126:15 problems 86:2, 86:8, 86:20, 87:12, 87:16, 88:7, 90:14, 91:18, 202:5, 203:4 proceeding 11:22, 12:3, 69:22, 174:11, 182:10, 266:21, 272:11 proceedings 10:18, 10:21, 11:15, 122:5, 158:8, 209:8, 216:7, 216:15, 219:7, 243:12, 243:19 proceeds 78:5 process 159:21, 159:22, 160:12, 170:13, 170:14, 178:21 processes 190:1 produce 19:14, 22:8, 128:5, 130:4, 131:2, 131:6, 232:8, 234:19
--	--	--	--

<p>produced 227:2, 267:21</p> <p>produces 90:10</p> <p>product 90:12</p> <p>production 97:18, 187:18, 188:2, 191:15, 196:19, 205:19, 206:2, 219:1, 265:5</p> <p>professor 7:21</p> <p>profile 25:10, 190:6, 190:14</p> <p>profoundly 205:1</p> <p>program 13:5, 13:6, 13:18, 268:13</p> <p>progression 104:11</p> <p>project 132:12</p> <p>prominence 81:9, 82:14</p> <p>prominent 80:12</p> <p>promise 84:4, 203:21</p> <p>promising 80:21, 85:1, 95:1, 96:3, 98:8, 118:9, 195:8, 198:18, 199:14, 200:4, 202:1, 204:6, 274:11</p> <p>promote 115:13</p> <p>prompt 78:19</p> <p>prompts 78:8</p> <p>proof 111:17, 197:3</p>	<p>properly 79:2</p> <p>properties 94:21, 96:2, 98:7, 270:22</p> <p>propose 84:10</p> <p>proposed 84:14</p> <p>proposing 84:11</p> <p>proposition 68:14, 194:7</p> <p>proprietary 25:22</p> <p>prospects 84:21</p> <p>protamine 192:13, 197:1, 197:11</p> <p>protamine-based 56:15, 56:18</p> <p>protect 21:10, 21:15, 23:2, 23:5, 88:4, 98:17, 197:6</p> <p>protected 72:13, 73:8, 112:21, 114:13</p> <p>protecting 113:11</p> <p>protection 20:3, 22:13, 23:13, 29:15, 40:18, 42:5, 59:9, 60:2, 60:10, 61:7, 61:17, 62:4, 72:14, 73:10, 73:19, 73:20, 93:22, 105:18, 114:1, 114:10, 118:19, 120:13, 120:16, 144:16, 187:9, 197:13, 256:7, 257:1</p> <p>protective 70:14, 71:1,</p>	<p>71:8, 154:11, 154:14, 154:16, 154:18, 256:12, 256:14, 256:19</p> <p>protectiveness 255:19</p> <p>protects 116:1</p> <p>protein-based 150:17, 261:20</p> <p>proteins 47:20, 65:11, 65:16, 77:6, 78:3, 94:5, 128:7, 187:3, 187:7, 226:10, 227:13, 230:11, 230:12, 258:13</p> <p>prove 210:15, 211:18</p> <p>proved 23:2</p> <p>provide 20:3, 25:9, 29:14, 40:17, 42:4, 56:11, 82:22, 83:4, 85:15, 120:12, 135:12, 135:15, 161:1, 163:19, 163:22, 164:3, 171:22, 172:12, 173:6, 176:9, 176:16, 177:19, 183:6, 212:15, 221:21, 221:22, 222:1, 228:9</p> <p>provided 41:21, 47:9, 78:21, 85:16, 85:17, 127:12, 128:2, 139:1, 161:22, 163:3, 163:20, 164:10, 171:14, 173:1, 175:20, 176:4, 178:4, 184:9, 239:13, 255:19,</p>	<p>263:15</p> <p>provides 108:3, 134:10, 222:2, 245:8</p> <p>providing 22:13, 26:19, 227:14, 263:22</p> <p>provisional 123:9</p> <p>provoke 212:19, 213:4, 217:12, 217:14, 221:18, 222:11, 222:15, 222:17, 237:13</p> <p>provokes 216:21, 222:5</p> <p>provoking 220:19</p> <p>pseudouridine 89:7, 90:2, 93:7, 93:8, 94:22, 97:10, 98:7, 99:8, 191:10</p> <p>pseudouridines 191:14</p> <p>public 2:14, 7:4, 77:10, 277:1, 277:3, 277:34</p> <p>publication 36:9, 39:14, 45:17, 67:1, 68:4, 68:6, 70:6, 72:2, 72:9, 89:12, 106:22, 107:2, 107:3, 190:22, 199:2, 200:8, 200:10, 207:6</p> <p>publications 44:6, 44:12, 45:2, 83:19, 195:15, 196:12, 236:19</p> <p>publish 34:13, 34:16</p>
---	---	---	--

published 31:13, 34:11, 34:16, 34:19, 34:21, 36:1, 36:21, 47:3, 47:18, 54:12, 57:13, 70:8, 70:10, 75:21, 79:18, 89:17, 92:6, 92:16, 95:22, 99:12, 100:21, 103:5, 193:21, 199:2, 258:11	Q qualification 185:5 qualifications 185:3 qualify 184:18, 185:14 quantify 228:10, 232:4, 275:6 quantitative 170:13 question 9:11, 9:18, 9:19, 10:14, 25:18, 27:10, 29:8, 38:22, 41:1, 41:2, 44:9, 48:14, 49:14, 50:20, 51:12, 59:22, 61:10, 62:10, 65:13, 82:20, 86:6, 87:8, 91:7, 91:16, 92:3, 92:9, 92:11, 95:10, 96:6, 100:5, 109:19, 113:18, 114:5, 115:9, 116:16, 136:21, 137:15, 145:9, 151:2, 151:4, 151:10, 152:4, 152:7, 154:8, 164:2, 171:7, 172:6, 173:19, 177:2, 177:5, 182:20, 190:19, 200:15, 207:1, 210:7, 214:22, 219:4, 220:9, 221:3, 221:13, 221:14, 224:14, 225:14, 231:10, 231:19, 233:16, 234:11, 243:16,	248:19, 253:18, 256:1, 258:4, 263:19, 264:4, 264:20, 266:9, 267:2, 267:7, 267:11, 267:14, 272:14, 272:20 questions 8:10, 9:10, 10:3, 10:12, 109:4, 172:9, 233:9, 254:14, 254:16, 255:1, 257:12, 257:20, 263:8, 263:14, 263:22, 275:21, 276:5 quickly 47:17, 84:12, 156:13 quite 33:16, 62:17, 62:22, 134:5, 158:15, 162:13, 194:4 quotation 198:14, 198:17 quote 184:2 quoted 6:13, 184:4	raises 248:19 range 23:13, 65:4, 65:6, 120:11, 121:6, 121:13, 121:22, 180:15, 193:19, 208:2, 273:13 ranged 180:13 rapid 74:11, 74:18, 191:19, 192:17, 193:1 rapidly 30:20, 74:21 rate 143:22 rather 124:12, 151:2, 153:18, 192:2, 200:1, 275:5 ratio 226:1, 226:4 ratios 136:7, 140:12 rbd 59:14, 60:7, 68:10 reached 13:16, 55:10, 55:22 read 6:14, 14:2, 36:11, 36:14, 98:4, 111:5, 111:22, 113:15, 115:7, 129:22, 134:22, 137:8, 139:9, 142:10, 142:13, 148:10, 168:13, 169:21, 176:1, 183:15, 183:18, 183:22, 184:1, 185:10, 198:16, 212:4, 212:7, 238:1,
pull 178:20, 254:20, 257:13 pulled 180:2, 210:5 pulmonary 58:8 purports 203:1 purpose 29:12, 106:1, 106:7, 152:5, 226:14, 226:16, 228:5 purposes 130:9, 130:11 pursuant 2:12 pursue 235:2, 246:6 pursuing 246:12 put 17:16, 77:10, 121:1, 163:2, 163:6, 165:17, 204:3, 234:16, 263:6, 265:10, 275:10 putting 124:15, 124:19, 160:3, 178:22, 179:2, 179:5, 179:7		R rabbit 138:13, 138:14, 138:20, 139:4, 139:6, 256:4 rabbits 132:6, 139:11, 139:12 rabies 178:12 raise 40:16, 40:20, 41:4, 41:16, 42:1, 84:2, 90:8 raised 9:12	

238:13, 240:20, 241:18 readily 49:5 reading 18:12, 70:16, 123:15, 127:22, 153:7, 175:14, 175:15, 175:19, 193:11, 193:13, 210:21, 211:1, 211:8, 237:22, 243:8, 250:4, 257:5 reads 19:8, 56:22, 58:4, 68:7, 76:15, 77:3, 112:19, 125:19, 153:5, 181:13 ready 90:16, 126:7 real 227:8 reality 80:11 realized 84:3 really 16:22, 26:17, 30:8, 32:11, 32:12, 73:1, 80:12, 81:3, 81:12, 90:1, 96:13, 117:15, 141:1, 169:22, 179:15, 180:4, 180:8, 180:13, 189:20, 201:3, 201:6, 203:17, 228:5, 231:11, 239:1, 245:8, 256:13, 264:7, 265:1, 270:18, 272:5, 274:16 reask 41:2, 49:15, 116:15, 221:13	reason 231:20, 232:2 reasonable 244:19, 245:21 reasonably 78:18, 130:21 reasons 33:18, 98:13, 129:9, 152:10 recall 12:15, 12:16, 12:19, 14:14, 16:5, 18:1, 43:6, 55:20, 59:4, 76:2, 76:3, 76:13, 87:3, 92:19, 119:12, 174:12, 174:13, 179:15, 256:11, 257:19, 263:7 receive 275:16 recent 18:16, 104:15, 105:7 recently 30:19, 118:18 receptor 59:14, 60:6, 62:13, 62:20, 68:10, 71:14, 144:8 recess 75:6, 157:10, 208:18, 247:1, 254:9 recipient 240:17 reciprocal 275:9 recognition 71:14, 93:8, 95:17 recognizable 108:8 recognize 35:14, 169:10,	198:10, 208:21 recognized 97:6, 126:10 recognizes 241:4 recognizing 177:20 recollection 239:20 recombinant 63:4, 65:21, 195:20, 196:3, 250:2, 258:13, 258:14, 259:9, 261:5, 262:2 record 6:13, 7:12, 59:21, 98:5, 142:7, 211:9, 221:8, 254:4, 275:20, 276:2, 276:3, 276:8, 277:9 redirect 254:14 redline 167:15 reduced 97:16 reduction 256:8, 257:10 reemergence 126:1 refer 11:5, 11:11, 28:13, 86:19, 91:2, 93:21, 158:20, 182:5, 182:9, 209:4, 220:2, 236:7, 242:21, 243:1 reference 69:4, 70:6, 72:5, 87:10, 89:1, 92:20, 107:10, 110:18, 121:20, 177:11, 178:1, 178:2,	181:17, 182:3, 182:6, 182:7, 182:11, 203:13, 209:14, 209:15, 209:17, 209:20, 209:22, 210:2, 210:8, 210:12, 211:16, 213:21, 214:5, 214:13, 214:19, 215:3, 215:8, 216:11, 217:20, 217:21, 218:8, 218:12, 219:21, 226:5, 235:20, 236:2, 236:6, 236:11, 237:17, 238:9, 238:18, 238:19, 247:9, 247:10, 247:13, 247:16, 250:5, 250:6, 250:8, 257:3 referenced 70:5, 91:1, 91:9, 91:12, 91:20, 175:16, 238:21 references 64:17, 68:15, 68:19, 68:21, 72:21, 85:14, 85:17, 85:20, 85:21, 87:12, 93:1, 111:1, 111:21, 121:19, 176:15, 176:18, 176:19, 177:14, 177:15, 177:22, 178:9, 180:21, 220:19, 236:19, 243:21, 244:5, 267:17 referencing 92:5, 92:15, 236:3, 237:5 referred 37:15, 37:17, 37:20, 86:14,
--	--	--	---

110:14 referring 16:10, 23:17, 24:11, 24:17, 24:22, 28:14, 31:10, 39:5, 64:17, 66:11, 73:13, 86:17, 88:11, 90:8, 93:15, 95:13, 111:3, 111:7, 113:4, 113:5, 130:6, 132:7, 133:11, 138:14, 138:15, 139:3, 140:13, 154:1, 154:5, 154:6, 174:19, 182:7, 182:8, 201:6, 202:11, 203:16, 205:9, 209:6, 211:11, 226:12, 237:5, 237:15, 238:16, 242:19, 250:5, 250:6, 251:20, 256:12 refers 86:15, 87:10, 90:7, 94:1, 94:2, 102:20, 134:9, 137:13, 158:12, 236:9, 237:10, 242:14 refine 228:12 reflective 202:16 reformat 162:22 regard 72:6, 216:13, 237:6 regarding 45:2, 72:3, 86:3, 216:5, 226:9, 255:18, 262:11, 263:11 regardless 116:11, 116:15,	116:18, 119:22 regimen 147:19, 148:19, 148:20, 150:13, 259:4 regimens 147:21 region 134:7, 135:3, 148:2, 260:5 regions 23:12, 26:16, 30:13 registered 2:13, 277:2 regulatory 207:8, 207:15 relate 219:3 related 14:22, 15:7, 15:22, 16:1, 16:20, 34:12, 42:14, 59:13, 60:5, 60:18, 61:6, 61:14, 68:9, 98:15, 159:5, 159:9, 179:9, 233:9, 247:16, 262:19, 277:22 relates 103:15, 158:21, 168:8 relating 34:19, 159:12 relative 274:21 release 126:1 relevance 234:16 relevant 58:22, 66:8, 66:16, 72:1, 166:14, 248:6, 249:2, 249:12, 264:16	reliable 48:18 relied 42:8, 62:5 rely 42:16, 42:21, 48:1, 48:3, 244:6 relying 44:2 remained 126:6 remaining 238:8 remains 119:4 remember 12:12, 16:11, 16:13, 16:14, 16:16, 16:18, 16:22, 17:19, 17:20, 55:18, 56:4, 56:5, 84:1, 96:12, 133:6, 142:12, 168:5, 168:17, 173:13, 176:11, 176:13, 177:18, 178:17, 179:4, 179:11, 198:5, 203:9, 247:18, 254:18, 255:3, 255:4, 266:6, 269:9 remind 59:18, 151:15, 202:10, 206:22 remotely 98:15 repeat 25:18, 59:22, 74:2, 91:7, 136:21, 192:20, 209:19, 215:1 rephrase 66:11 replace 96:19, 97:1	replacement 95:1, 96:4, 98:8, 200:5, 265:5 replicon 5:12, 35:8, 37:10, 37:14, 37:19, 38:10, 67:19 replicons 52:18 report 181:1, 181:4, 186:15 reported 1:26 reporter 2:13, 9:22, 10:7, 18:4, 35:3, 75:11, 142:4, 226:10, 226:14, 226:16, 226:19, 226:21, 227:4, 227:7, 227:8, 227:10, 227:12, 227:13, 230:15, 230:18, 231:5, 231:10, 231:14, 231:20, 232:2, 232:11, 232:16, 233:1, 233:4, 233:17, 233:20, 263:9, 263:16, 264:14, 264:22, 276:6, 277:1, 277:3 reporting 200:9 reports 72:12, 73:7, 147:10, 252:22 represent 88:16, 102:7 represented 277:13 represents 71:15 reprna-cov2s 37:10
--	--	---	--

<p>require 187:17, 188:1, 192:4</p> <p>required 53:20, 99:5, 114:16, 123:11, 153:22, 154:10, 155:12, 155:17, 156:1, 160:19, 205:18, 206:1, 213:16, 213:21, 214:5, 214:15, 214:20, 215:4, 215:6, 236:1, 236:5, 255:2, 257:6</p> <p>requirement 186:4</p> <p>requires 155:19, 186:1</p> <p>requiring 74:12</p> <p>reread 14:3, 212:2</p> <p>research 8:2, 18:18, 19:1, 19:7, 32:8, 34:12, 34:19, 48:17, 83:19, 129:7, 129:15, 177:12, 178:2, 184:16, 184:19, 189:16, 194:17, 200:3, 200:11, 201:12, 201:22, 252:3, 252:8, 259:19, 268:4, 268:13, 271:11</p> <p>researcher 31:14, 63:14, 84:10</p> <p>researchers 63:11, 86:1, 86:7, 86:19, 101:13, 114:3, 184:15, 202:5, 203:3</p>	<p>resources 174:20, 178:22, 179:3, 179:6</p> <p>respect 93:16, 164:10, 183:7</p> <p>respective 161:17</p> <p>respiratory 57:1, 73:9, 118:15, 118:16, 125:19, 142:20, 142:21, 143:4, 143:5, 143:13</p> <p>respond 84:12</p> <p>responses 5:14, 25:13, 26:15, 26:19, 26:20, 29:14, 30:5, 35:9, 40:16, 40:21, 41:17, 47:14, 48:2, 50:12, 56:10, 59:16, 60:8, 67:22, 68:12, 70:13, 70:22, 71:7, 97:7, 144:11, 149:13, 197:5, 217:12, 217:15, 251:10, 252:9, 252:11, 253:3, 258:19, 259:7, 270:15, 270:17, 272:2, 273:5, 273:6, 273:14, 274:17, 274:18, 274:20, 274:22, 275:3, 275:4</p> <p>rest 115:7</p> <p>restate 44:10, 61:11, 190:11</p> <p>restroom 246:21</p> <p>result 25:12, 128:20,</p>	<p>133:18, 144:21, 189:17, 191:10, 251:5, 259:20, 271:7</p> <p>resulted 38:19, 39:2, 67:22, 165:11, 250:20, 259:4, 259:6</p> <p>results 34:17, 109:10, 109:16, 110:3, 111:7, 111:9, 111:13, 111:16, 112:3, 112:6, 113:5, 147:4, 147:10, 148:15, 198:18, 199:14, 262:10, 272:18</p> <p>review 14:21, 15:2, 15:5, 15:6, 15:15, 16:3, 16:9, 76:6, 76:8, 100:22, 122:9, 177:10, 200:20</p> <p>reviewed 14:18, 15:15, 16:19, 35:22, 42:10, 65:4, 67:4, 76:9, 85:17, 87:1, 100:20, 101:1, 101:3, 168:1, 168:17, 170:3, 171:9, 171:19, 174:6, 198:3, 203:11, 239:7, 239:10, 255:15</p> <p>reviewers 84:21</p> <p>reviewing 15:22, 117:16, 160:6, 175:17, 175:19</p> <p>reviews 65:2, 68:21,</p>	<p>176:20</p> <p>revise 161:19, 162:22</p> <p>revised 167:1, 169:3, 170:20, 171:11, 172:3</p> <p>revising 160:6</p> <p>revisions 123:11, 170:15</p> <p>revisit 190:17</p> <p>ribonucleic 127:13, 128:2, 153:6</p> <p>right-hand 118:1, 204:15</p> <p>risk 152:21, 189:6, 189:12, 189:19, 189:21, 251:15, 251:16, 261:6, 261:8</p> <p>rmr 1:26</p> <p>rna-based 29:10, 29:20, 106:5, 106:7</p> <p>rnas 118:6, 197:20</p> <p>rnase 112:22, 113:12, 113:20, 113:21, 114:2, 114:7, 114:9, 114:10, 114:21</p> <p>rnases 88:5, 93:13, 93:22, 116:3</p> <p>robust 59:15, 60:8, 68:11, 90:9, 145:16, 258:12, 259:11</p> <p>role 26:18, 207:8, 207:15</p>
---	--	---	---

room 14:6 roster 178:12 routinely 129:14 row 167:14 rsv 118:7, 118:9, 118:12, 118:19, 118:21, 119:3, 119:8, 119:11, 239:19, 245:9 rules 214:3 run 167:11, 214:16 runs 161:7 ryan 3:6	29:9, 33:3, 40:19, 41:10, 44:17, 47:4, 51:17, 51:21, 59:19, 80:10, 84:21, 99:1, 167:6, 170:5, 171:18, 172:2, 173:4, 188:10, 188:12, 198:17, 203:17, 221:12, 229:21, 230:2, 249:17 same 10:9, 24:7, 26:2, 27:21, 29:1, 29:3, 29:9, 29:19, 30:12, 31:6, 31:20, 33:9, 41:6, 44:15, 48:11, 48:17, 49:22, 54:13, 67:20, 80:21, 91:22, 92:18, 101:16, 109:2, 112:18, 115:3, 116:11, 116:14, 116:17, 117:22, 125:12, 133:19, 146:18, 162:5, 164:19, 167:3, 175:4, 176:6, 176:14, 180:21, 190:16, 199:19, 206:21, 210:3, 210:20, 211:10, 215:21, 218:10, 219:8, 220:10, 221:4, 221:12, 224:22, 228:18, 230:1, 231:3, 231:7, 231:17, 233:11, 236:21, 248:14, 253:18, 269:11, 270:4, 270:12, 271:9, 272:1, 272:16,	272:18, 273:16, 275:16 sarna 38:10, 45:3, 67:14, 68:20, 119:16, 187:16, 187:22, 266:10, 272:15 sars 68:22, 71:16, 125:20, 126:1, 126:8, 241:16, 241:22 sars-cov 40:14, 42:12, 58:13, 58:14, 59:20, 60:5, 60:18, 61:6, 61:14, 62:12, 62:19, 63:1, 63:22, 64:6, 64:14, 65:4, 65:6, 65:10, 65:15, 66:4, 66:12, 67:9, 68:9, 69:2, 69:9, 70:15, 71:2, 71:5, 71:9, 71:13, 72:13, 73:8, 73:17, 246:15, 250:19 sars-cov-1 42:12, 44:1, 74:3 sars-cov-2 5:13, 19:9, 20:19, 20:22, 21:6, 22:11, 23:3, 23:5, 23:7, 31:13, 35:8, 37:11, 38:9, 38:19, 38:20, 39:2, 39:3, 39:16, 40:10, 41:12, 42:7, 42:19, 42:22, 47:18,	48:10, 57:3, 57:6, 57:9, 57:12, 57:18, 57:22, 58:12, 59:13, 59:20, 62:6, 66:18, 72:4, 72:15, 73:10, 73:21, 131:14, 131:16, 131:20, 131:21, 251:4, 251:7, 251:18 sat 166:19 satisfactorily 7:3 saw 33:16, 202:3, 256:7 say 18:9, 21:14, 27:15, 28:9, 29:18, 30:7, 34:18, 36:16, 50:14, 61:4, 71:4, 73:20, 78:17, 79:20, 80:1, 80:11, 80:19, 81:6, 81:9, 81:20, 82:2, 82:3, 88:20, 89:19, 96:19, 100:8, 105:22, 113:1, 116:10, 119:20, 120:20, 121:13, 121:20, 124:1, 124:3, 128:22, 129:5, 129:12, 129:19, 130:20, 131:3, 134:4, 135:9, 136:15, 137:1, 143:2, 146:19, 146:20, 150:7, 154:16, 154:18, 154:19, 154:21, 155:4, 156:1, 161:11,
s 129:17, 147:20 sl 113:6, 117:15, 145:16, 147:10, 147:15, 147:16, 147:21, 148:6, 148:8, 148:12, 149:10, 151:22, 152:3, 259:14 s2 132:21, 141:8 sab 13:21 safe 86:11, 203:8 safely 128:4, 130:3, 131:1 safety 190:6, 190:14, 190:17, 191:3 said 14:10, 14:18,			

162:17, 163:8, 164:13, 167:14, 188:20, 195:22, 200:8, 200:22, 205:11, 213:19, 214:4, 218:7, 219:10, 219:15, 219:17, 228:14, 228:21, 232:3, 234:2, 242:18, 244:3, 244:16, 249:11, 264:10, 268:5, 270:12, 270:16, 271:16 saying 27:18, 27:19, 107:5, 110:15, 125:13, 155:14, 156:7, 156:8, 163:17, 167:13, 171:16 says 12:5, 19:19, 24:19, 30:19, 37:9, 57:11, 60:9, 70:20, 71:13, 76:1, 76:19, 79:8, 79:13, 80:2, 86:7, 94:17, 95:3, 98:6, 104:14, 105:7, 105:12, 108:22, 109:12, 110:10, 111:10, 112:10, 112:15, 117:4, 117:6, 117:8, 117:10, 118:4, 123:1, 128:2, 132:18, 136:3, 139:16, 139:18, 141:10, 145:14, 147:14, 148:12, 148:18, 154:20, 156:19, 158:12, 168:12, 181:11, 181:18, 182:4, 204:22, 205:4,	236:13, 237:7, 237:16, 238:3, 238:17, 240:13, 241:8, 241:13, 241:15, 241:19, 242:7 schrum 182:5, 182:10, 209:3, 209:5, 211:21, 212:8, 212:12, 212:15, 212:18, 215:13, 215:19, 216:6, 216:10, 216:11, 216:14, 216:16, 217:18, 218:17, 219:6, 219:17, 220:15, 220:18, 221:15, 222:20, 222:22, 224:6, 224:9, 224:19, 225:1, 225:5, 225:16, 226:3, 226:8, 226:9, 226:19, 235:10, 235:12, 235:14, 236:9, 238:10, 244:6, 244:7, 244:18, 244:21 schrum's 182:14, 182:16, 182:18, 182:22 science 161:15, 165:21, 251:20 scientific 13:17, 13:19, 36:8, 42:8, 42:14, 54:7, 54:11, 69:17, 104:8, 107:18, 160:14 scientist 15:21, 98:10, 144:13, 150:7, 160:1 scientists 21:14, 22:19,	34:14 scope 228:3, 229:16, 229:19, 229:21, 230:21, 231:8, 231:18, 232:15, 232:19, 233:6, 233:22, 234:9 scratch 230:16 se 1:5, 3:4, 7:7, 48:10, 204:3 seap 226:22, 264:22 season 19:15 seat 79:9 seattle 47:8 second 68:5, 79:4, 100:1, 101:12, 101:18, 101:19, 101:21, 102:9, 102:17, 104:13, 104:14, 105:3, 105:5, 107:20, 116:6, 144:5, 147:5, 147:9, 199:5, 199:10, 204:18, 236:2 section 23:22, 76:18, 111:13, 111:16, 112:3, 112:6, 113:5, 147:4, 164:18, 166:1, 166:17, 166:21, 168:8, 168:9, 168:11, 168:16, 168:20, 169:1, 181:1, 181:2, 181:4, 181:8, 181:12, 183:17, 220:3, 225:8, 226:11	sections 96:10, 162:14, 164:13, 164:15, 166:7, 167:8, 167:16, 167:18, 167:20, 168:2, 169:1, 169:2, 169:3, 169:4, 169:5, 169:9, 169:10, 169:16, 169:18, 169:20, 170:1, 170:2, 220:5 secured 108:11 seeing 129:9, 224:13, 262:6, 273:11 seek 29:18, 30:12 seemed 53:11, 82:10, 229:20 seems 187:20 seen 18:6, 103:1, 142:10, 142:11, 204:6, 259:3 select 40:8 selected 39:20, 40:1, 40:3, 40:5 selecting 43:8 selection 27:16, 42:7, 251:17 self-amplified 66:17 self-amplifying 24:3, 25:5, 25:6, 27:11, 28:11, 29:4, 30:9, 32:17, 33:2, 37:15, 37:18, 38:2,
--	--	---	---

38:6, 38:7, 43:10, 43:16, 43:19, 45:7, 46:4, 66:4, 66:6, 66:9, 66:20, 66:22, 67:5, 67:10, 71:20, 72:3, 72:7, 84:15, 102:13, 103:17, 104:5, 104:12, 104:18, 105:10, 107:1, 111:18, 116:12, 116:19, 118:5, 119:16, 120:18, 121:3, 121:10, 121:19, 122:2, 129:16, 188:17, 194:22, 195:7, 195:16, 237:12, 237:14, 239:19, 245:5, 269:20, 270:3, 270:20, 272:6, 273:3, 273:15 self-replicating 37:20, 37:22, 119:16 seminar 84:5 sense 100:15, 157:9, 214:22, 229:4, 231:22, 270:22 sensed 274:1 sensing 271:2 sentence 24:14, 24:18, 36:4, 37:8, 53:2, 68:6, 71:18, 74:8, 76:18, 77:3, 79:5, 79:7, 94:3, 98:5, 98:6, 101:18, 104:13, 104:14,	105:3, 105:5, 114:15, 114:21, 114:22, 115:5, 127:22, 129:22, 143:11, 144:5, 163:10, 199:6, 199:13, 199:19, 199:22, 204:18, 207:5, 211:9 sentences 94:17, 115:1, 167:14, 169:6, 199:22 september 103:5, 103:8, 106:18 sequence 22:15, 23:7, 29:2, 31:12, 31:15, 47:18, 57:12, 57:19, 58:2, 74:13, 78:6, 79:1, 86:11, 119:3, 134:7, 141:13, 203:7, 205:1, 205:12 sequenced 57:15, 58:1 sequences 27:1, 27:2, 27:6, 28:22, 47:19, 77:14, 133:8, 133:16, 133:17, 133:20, 133:22, 134:10, 135:10, 242:13, 242:20 sequencing 228:15 series 9:9 seriously 213:12, 213:13 serum-neutralizing 145:17 serve 13:17	set 13:9, 46:6, 258:1, 277:6, 277:29 seven 79:14, 80:2, 80:16, 81:20, 82:3, 180:1, 199:16, 203:2 seven-sentence 163:15 several 46:18, 63:9, 145:17, 162:12, 179:18, 203:18, 223:21, 226:7 severe 57:1, 125:19, 142:21, 143:5 share 123:17, 125:3, 125:7, 125:11, 177:21, 178:17, 178:21 shared 55:11, 85:10 shebang 239:1 shifting 257:11, 266:2 short 61:2, 104:16, 105:8, 275:19 short-circuit 113:9 shortened 150:6 shorthand 277:1 shortly 60:20 should 20:1, 40:17, 42:4, 59:20, 75:4, 157:8, 169:13 show 30:1, 97:15,	101:15, 104:10, 131:5, 145:15, 201:4, 203:20, 219:2, 256:21, 264:15 showed 40:19, 41:3, 97:9, 112:20, 116:22, 170:17, 191:13 showing 83:20, 98:19, 260:9, 268:20 shown 23:12, 30:19, 72:12, 72:20, 73:7, 103:14, 186:15, 189:16, 244:17, 256:16, 258:21, 261:16, 262:11 shows 98:15, 150:22, 151:12, 151:22 shut 93:19 shutting 97:20 sic 59:13 side 172:16, 173:10, 173:11, 173:15, 263:6 sign 171:14 signal 231:15, 232:12, 232:17 signature-plkal 277:32 signed 85:19, 174:7 significant 23:13, 26:18, 47:13, 256:7, 257:9 significantly 147:19, 148:19,
---	--	--	---

150:18, 151:6 similar 125:16, 158:15, 158:16, 159:4, 159:22, 248:17, 253:15, 269:1 similarities 123:21, 124:14, 125:4, 125:5, 270:2 similarly 19:8, 23:10, 24:19, 57:20 simply 22:14, 61:1, 83:16, 126:12, 146:21, 177:20, 189:12, 195:10 since 171:9, 191:9, 269:16, 271:13 single 27:9, 166:10, 166:16, 181:16, 189:16, 201:2, 209:17, 210:1, 210:11, 211:15, 248:18 sirna 104:16, 105:9 sit 165:15 sitting 166:12, 166:15, 169:10 situation 30:6 six 53:1, 58:3, 113:1, 113:6, 117:13, 117:18, 268:22 skeptical 194:8, 194:16 skepticism 85:4, 98:12, 194:13, 195:4, 195:9, 196:7	skill 130:20, 168:15, 183:8, 243:13, 257:5, 262:10, 263:10 skin 52:6 slow 127:17, 164:5, 176:21, 255:11, 267:3 solely 127:9, 144:8 solve 91:13, 91:17, 126:15 solved 86:2, 86:7, 86:20, 87:22, 88:7, 90:15, 200:12, 202:5, 203:4 solving 89:21, 91:2, 91:20 some 8:16, 9:7, 14:13, 16:5, 19:5, 31:11, 45:18, 45:19, 45:22, 48:22, 49:11, 49:20, 50:5, 51:9, 52:11, 55:2, 63:9, 65:7, 80:16, 81:7, 81:16, 83:3, 83:5, 84:2, 84:4, 85:16, 90:14, 97:14, 108:7, 113:9, 116:12, 116:19, 117:19, 119:2, 120:4, 120:6, 124:9, 125:5, 131:9, 137:11, 137:12, 137:16, 142:11, 142:17,	164:17, 167:16, 167:20, 168:14, 169:3, 175:21, 176:12, 176:18, 187:21, 196:5, 196:11, 196:12, 196:15, 196:20, 196:21, 197:10, 201:15, 206:10, 206:12, 231:15, 233:3, 233:19, 234:16, 236:19, 253:10, 254:1, 254:13, 254:16, 255:1, 257:12, 257:19, 263:8, 274:13 somebody 73:15, 78:13, 163:11, 167:9 someone 57:16, 57:20, 78:11, 161:2 something 13:10, 52:15, 58:22, 61:3, 98:21, 144:3, 163:13, 168:20, 169:13, 179:9, 210:21, 213:4, 213:10, 226:22, 229:2, 238:2, 238:4, 238:14, 238:15, 242:14, 244:13, 246:4, 253:4, 261:12, 264:11, 269:1, 273:11 sometime 80:7 sometimes 265:19, 272:2, 272:3 somewhat 119:9 somewhere 193:11, 203:19, 236:7	soon 5:17, 75:14 sooner 9:17 sorry 34:5, 41:12, 53:1, 59:19, 74:2, 90:6, 99:16, 104:20, 109:12, 127:15, 147:8, 156:7, 164:5, 199:12, 208:7 sort 81:12, 82:7, 126:14, 160:18, 197:2, 197:13, 213:6, 214:1, 227:14, 230:4, 230:5, 234:15, 248:14, 248:18, 262:7, 268:10 sorts 88:4, 126:21, 160:6, 160:18, 223:5, 230:11, 269:3, 270:21 source 141:2 speak 83:13, 207:22, 218:16 speaking 171:12, 172:5, 243:5, 263:7 specht 4:5 specific 43:2, 48:15, 65:14, 73:1, 87:7, 138:13, 139:6, 139:7, 156:9, 163:9, 164:12, 170:18, 172:17, 172:22, 173:12, 191:8, 213:7, 218:22, 225:13, 243:7,
--	--	--	---

248:21 specifically 32:2, 42:12, 66:12, 72:6, 81:4, 131:13, 133:10, 138:20, 177:19, 179:10, 234:1, 242:3, 243:17, 255:5, 257:17 specification 123:17, 123:21, 124:1, 124:3, 124:6, 125:7, 125:8, 255:16 specificity 16:5 specifics 134:16, 135:5, 135:9 specified 17:14, 82:15 specify 15:20, 44:16, 134:6, 186:18 spend 173:20, 174:3, 179:2 spent 179:12 spike 22:15, 31:19, 37:11, 38:9, 38:11, 38:12, 38:13, 38:19, 38:20, 39:2, 39:3, 39:11, 39:16, 40:10, 40:17, 40:21, 41:5, 41:17, 41:22, 42:8, 42:22, 43:8, 45:10, 50:9, 50:21, 51:7, 53:9, 53:13, 53:16, 53:18, 54:1, 54:5, 57:17, 57:22,	58:21, 59:5, 65:5, 65:7, 65:11, 65:16, 69:1, 69:9, 71:21, 72:4, 72:6, 73:5, 132:21, 132:22, 133:21, 134:1, 134:11, 141:7, 141:8, 141:12, 141:15, 141:18, 144:9, 146:1, 146:3, 146:10, 146:12, 150:4, 150:6, 152:15, 235:15, 235:16, 239:16, 241:10, 241:20, 241:21, 242:4, 242:8, 242:9, 242:10, 242:12, 242:16, 242:17, 243:3, 243:4, 243:8, 246:9, 259:17, 260:1, 260:10, 261:12, 261:14, 262:21, 263:12, 270:12 spread 125:21, 180:19 spring 269:4 stability 33:14, 52:20, 88:2, 89:9, 89:22, 90:7, 90:11, 90:17, 91:18, 93:10, 93:15, 93:16, 93:19, 93:22, 94:19, 95:8, 95:11, 95:12, 95:14, 95:18, 99:14, 100:5, 100:16, 105:20, 195:14, 204:16, 205:2, 205:6, 205:7, 207:9	stable 191:5, 191:11 stages 100:11 standard 181:19, 183:7, 211:10, 217:17 standardize 208:9 standardized 207:17, 208:12, 227:16 standards 168:8, 168:12, 181:2, 181:5, 181:9 start 78:8, 78:19, 79:17, 80:12, 80:20, 82:13, 115:5, 121:21, 121:22, 124:10, 166:2, 179:8, 201:4, 268:15 started 31:11, 32:7, 33:1, 79:14, 79:21, 80:17, 80:19, 82:4, 83:20, 83:21, 84:2, 104:2, 127:7, 128:15, 128:21, 129:2, 129:16, 179:4, 179:5, 203:3, 203:20, 269:14, 269:19 starting 121:5, 201:18 starts 115:6, 144:6, 153:20, 199:13, 240:8 state 2:5, 4:7, 7:11, 7:14, 72:11, 141:7, 184:17, 187:20, 203:1,	244:11, 246:1, 246:4, 262:7, 277:19 stated 202:4, 237:4 statement 37:7, 72:18, 73:6, 77:7, 81:19, 107:4, 130:2, 133:12, 133:13, 188:12, 212:16, 213:10, 215:12, 221:20, 238:15 statements 36:18, 202:3 states 1:1, 23:10, 59:9, 60:1, 70:11, 74:6, 86:1, 114:16, 127:12, 142:19, 143:3, 143:17, 182:2, 207:7, 209:14, 209:20, 210:8, 221:17, 224:2 statistically 152:2, 257:9 stay 29:1 step 113:10, 145:5, 197:7, 230:6, 232:1, 232:3, 232:6 steps 187:18, 188:2, 208:11 stick 169:15 still 50:19, 83:7, 104:22, 121:6, 122:1, 126:10, 129:13, 129:18, 131:9, 133:18, 143:19, 177:1,
---	--	---	--

189:18, 192:7, 194:8, 196:5, 221:4, 221:6, 228:19, 229:8, 253:21 stimulate 235:3 stimulating 234:20 stop 22:8 stopped 269:15 story 260:21, 260:22 strain 19:10, 20:17, 133:3 strains 20:4, 20:11, 23:14, 145:18 strategies 33:11, 33:22, 34:2, 258:12 strategy 152:16, 260:1 street 2:5, 4:7, 277:19 strengthens 213:18 strong 214:8, 214:11, 235:3 structural 38:13, 133:19, 136:6, 136:11, 140:6, 140:11, 156:10 structure 160:18, 205:18, 206:1, 208:3, 242:15 structured 167:12, 242:21 student 269:22 students 271:15	studied 127:9, 261:17 studies 31:11, 47:2, 47:3, 47:22, 61:16, 61:20, 62:5, 63:8, 97:9, 111:3, 111:4, 121:16, 195:10, 196:21, 253:15, 253:17, 259:17 study 26:9, 29:12, 35:20, 45:21, 56:16, 63:20, 73:2, 73:14, 117:14, 132:18, 137:16, 138:13, 138:14, 138:16, 138:20, 139:4, 139:6, 139:10, 191:13, 246:3, 256:3, 256:4, 261:1, 262:19, 263:1, 268:5 studying 29:16, 268:1 stuff 161:13, 161:15, 174:20, 175:15 subject 15:8, 153:6, 153:10, 154:2, 154:4, 255:7 submission 160:14 submitted 11:14, 84:19, 158:8 subsection 147:5, 147:9 subset 111:19, 273:8 substance 9:6 substantial 198:19, 199:15,	274:3 substantively 158:15 substituted 133:18 subunit 38:16, 132:22, 141:8, 145:16, 150:19, 151:22, 152:3, 153:9, 153:12, 242:15, 255:8, 259:14 subunit-based 151:8, 151:17 subunits 156:11 success 45:18, 129:10, 230:7, 232:11, 232:12, 232:16, 232:17, 244:19, 245:22, 246:17 successful 32:21, 46:10, 46:13, 118:18, 128:16, 128:21 sudden 148:14 sufficient 22:13, 42:1, 100:18, 120:12, 238:6, 256:6, 257:1, 261:4 suggested 40:15, 41:16, 61:17, 82:20 suggesting 72:14, 73:10 suggestive 227:22 suggests 205:15 summarize 68:22 summarizing 205:14 summary 127:12, 127:20,	128:1, 171:1, 171:4, 171:8, 171:13, 171:19, 171:21, 172:11, 172:21, 173:5 superior 30:3, 80:22, 89:7 supplement 113:2 support 36:18, 54:18, 73:6, 99:7, 213:8, 215:11 supporting 71:10, 212:16 sure 18:12, 29:8, 36:17, 40:4, 40:7, 41:3, 49:16, 61:1, 75:5, 89:4, 119:14, 145:12, 145:14, 160:10, 162:22, 175:2, 175:4, 185:9, 208:17, 214:4, 214:7, 215:22, 224:14, 231:19, 233:7 surface 58:7, 186:14, 186:19, 186:21, 187:3, 187:4, 241:9 surfaces 187:6 surprise 271:6 surprising 260:12, 270:19 surprisingly 260:10 surrogate 227:19, 227:21 surrounding 63:8, 115:22, 195:4
---	---	---	---

sw 3:16 swap 29:1, 228:14, 275:10, 275:14 swapped 48:9 swapping 22:15 swaps 56:5 switch 158:3 sworn 7:4, 277:7 syncytial 118:15 syndrome 57:1, 73:9, 125:20, 142:20, 143:4 synergy 262:6 system 48:17, 53:8, 53:13, 53:19, 54:1, 54:5, 55:2, 55:10, 55:13, 55:22, 56:7, 56:15, 56:19, 93:9, 97:6, 108:4, 263:9, 263:12, 263:17, 264:14, 264:18, 266:17 systemic 104:15, 105:8 systems 53:6, 53:7, 55:7, 55:8, 88:9, 233:2, 233:18, 265:3, 266:13	70:13, 70:22, 71:7, 270:17, 272:2, 273:8, 274:17, 275:3, 275:4 t-cells 274:18 table 113:2, 113:6, 117:13, 117:15, 161:14, 161:15, 166:6, 166:8, 166:21, 168:11, 169:15, 178:20 tables 134:10 tail 135:6, 135:7, 135:8, 207:7, 207:14 tails 207:19 take 9:15, 9:16, 19:5, 22:7, 37:7, 68:17, 75:4, 79:15, 79:21, 80:13, 80:17, 81:9, 82:5, 82:13, 83:21, 107:21, 111:5, 113:10, 133:6, 135:20, 136:1, 152:19, 153:2, 157:7, 171:8, 171:18, 172:18, 173:12, 176:5, 197:8, 203:3, 208:15, 212:2, 213:11, 213:13, 225:8, 237:20, 244:1, 246:20, 246:22, 254:8, 268:20 taken 9:19, 145:6, 277:8 taking 45:9, 81:22,	104:14, 105:7, 174:20 talk 10:8, 21:21, 22:3, 119:1, 139:11, 158:6, 164:6, 165:19, 165:21, 169:16, 180:14, 190:19, 193:3, 193:4, 194:21, 237:11 talked 47:15, 78:22, 90:18, 94:11, 94:13, 114:21, 122:4, 145:11, 156:12 talking 10:7, 46:15, 64:8, 64:9, 64:11, 74:3, 81:3, 81:22, 90:13, 100:6, 100:9, 112:5, 113:11, 113:16, 114:20, 123:21, 130:14, 137:14, 138:10, 138:12, 139:9, 140:11, 145:21, 148:14, 155:13, 165:10, 174:15, 175:3, 187:2, 208:4, 217:17, 226:8, 245:5 talks 187:11, 239:18 target 23:11, 29:19, 30:12, 41:22, 42:2, 69:2, 69:7, 69:9, 74:12, 118:8, 118:21, 119:1, 145:2, 260:15 targeted 119:5, 187:7, 226:20	targeting 26:11, 26:16, 73:3, 155:9, 260:4 targets 71:16 teach 98:18, 151:5, 234:5, 245:3, 255:18, 271:14 teaches 94:4, 150:16, 151:11, 205:11, 219:17, 256:2 teaching 201:20, 265:12 team 184:15, 184:19 teams 204:4 technical 77:11, 232:9 technically 243:5 techniques 193:20 technological 101:9, 101:12, 200:2, 200:11, 200:17, 201:21 technologies 32:8, 86:9, 101:14, 101:21, 101:22, 102:19, 103:12, 103:19, 107:5, 193:20, 202:7, 203:5, 218:19 technology 32:9, 104:1, 131:4, 168:19, 226:18, 228:12, 258:2 tell 168:2, 173:14 tells 154:13 template 207:11
T			
t-cell 26:19, 30:5, 30:11, 35:9,			

<p>ten 23:9, 180:6, 180:7, 180:10, 201:9, 203:22</p> <p>tends 275:2, 275:4</p> <p>term 38:2, 155:5, 182:5</p> <p>termed 47:13</p> <p>terming 137:12</p> <p>terms 16:6, 16:19, 21:21, 24:22, 45:18, 73:3, 78:22, 82:1, 100:16, 120:15, 138:10, 141:2, 161:4, 161:16, 163:7, 165:13, 169:11, 175:11, 179:6, 184:7, 195:14, 196:16, 204:2, 210:18, 214:2, 218:5, 223:3, 231:9, 236:3, 264:9, 264:10, 270:2, 270:15</p> <p>test 26:4, 28:4, 45:8, 45:12, 49:2, 118:4, 121:11, 132:18, 139:10, 197:8, 228:16, 228:18</p> <p>tested 45:14, 50:13, 63:5, 63:6, 120:19, 194:5, 206:10, 228:20, 250:19, 260:7</p> <p>testified 7:5, 8:5, 42:4, 164:7, 266:2</p> <p>testify 8:14, 10:18</p>	<p>testimony 9:2, 38:1, 41:10, 51:19, 54:10, 156:6, 163:3, 163:14, 163:16, 163:19, 163:22, 166:19, 172:7, 185:4, 203:13, 208:5, 246:7, 246:10, 246:11, 277:9</p> <p>testing 45:17, 49:9, 49:18, 55:12, 62:16, 90:19, 117:18, 150:3, 266:17, 267:5</p> <p>text 76:8, 162:18, 163:4, 164:8, 236:8, 236:10</p> <p>th 75:22, 122:20, 186:11</p> <p>th1 252:11, 252:15, 253:9, 253:12, 253:19</p> <p>th2 252:8, 253:3, 253:19</p> <p>thank 69:12, 254:8, 276:5, 276:7</p> <p>themselves 93:14, 123:22</p> <p>theoretical 83:5, 99:6, 189:12, 189:19</p> <p>theoretically 26:13, 28:16, 74:17, 90:10, 203:21, 217:10</p> <p>theory 83:14, 116:20</p> <p>therapeutic 69:2, 69:8, 69:10, 94:6,</p>	<p>96:11, 97:8, 100:15, 100:18, 128:8, 130:7, 130:9, 130:11, 131:6, 178:11, 200:4, 202:1, 206:5, 216:21, 217:5, 218:19, 227:14, 228:1, 228:15, 229:6, 229:9, 229:13, 230:11, 230:19, 231:6, 231:16, 232:1, 232:17, 234:19, 235:6, 264:11, 265:1, 265:4, 265:11</p> <p>therapeutics 71:17, 96:9, 100:3, 100:4, 100:9, 182:19, 186:5, 198:20, 216:18, 216:20, 217:10, 226:20, 227:20, 229:18, 231:12, 244:22, 245:1</p> <p>therapy 81:15, 81:17, 96:18, 192:9, 197:20, 200:6</p> <p>therefore 188:7, 189:5</p> <p>thesis 269:22</p> <p>thing 29:3, 48:8, 100:1, 100:2, 109:2, 126:17, 146:18, 166:4, 172:17, 172:22, 173:12, 222:5, 236:21, 246:5, 248:15, 273:11</p> <p>things 10:4, 15:5, 15:16, 15:19, 88:4, 93:13,</p>	<p>106:4, 120:1, 123:12, 126:22, 130:17, 137:12, 149:7, 165:20, 168:13, 168:14, 169:19, 197:16, 203:15, 203:18, 203:21, 217:14, 222:10, 222:14, 228:10, 229:10, 230:13, 241:10, 244:12, 252:16, 261:18, 265:9</p> <p>think 15:16, 17:22, 21:22, 32:14, 41:10, 49:1, 51:17, 51:19, 53:1, 67:8, 67:10, 82:18, 84:3, 95:13, 96:22, 119:12, 124:11, 140:13, 146:4, 149:21, 149:22, 157:9, 176:11, 180:2, 180:17, 191:22, 195:6, 203:14, 206:14, 206:15, 207:6, 211:1, 213:5, 214:1, 215:21, 218:5, 229:17, 230:22, 262:3, 264:6, 269:11, 270:19, 271:11</p> <p>thinking 81:21, 96:17, 179:4, 245:21, 268:15</p> <p>third 37:8</p> <p>thought 42:18, 59:10, 60:2, 60:11, 60:14, 61:7, 61:17, 84:16, 97:19, 203:1,</p>
---	--	--	--

219:12, 268:18 thousands 245:12 threat 22:18 three 25:8, 25:9, 26:4, 27:20, 70:19, 76:4, 149:6, 149:8, 152:1, 163:10, 179:19, 179:20, 258:5, 259:6, 270:5, 270:8 throat 99:17 through 64:18, 68:15, 68:19, 72:15, 73:11, 73:12, 73:22, 129:11, 144:17, 160:10, 161:20, 165:19, 166:3, 166:4, 166:16, 167:11, 167:22, 168:14, 169:18, 169:22, 170:6, 170:7, 170:8, 175:14, 176:1, 189:13, 223:3, 256:3, 267:16 throughout 11:6, 11:12, 269:17 thursday 17:7, 17:11 tightly 161:21 time 9:3, 17:18, 22:20, 31:7, 32:16, 34:1, 56:3, 61:5, 61:12, 61:17, 66:6, 74:1, 75:1, 79:8, 80:6, 80:16,	82:11, 84:3, 100:12, 100:17, 123:11, 127:8, 131:8, 133:7, 135:14, 162:20, 174:22, 176:14, 180:9, 180:17, 180:18, 195:9, 201:7, 201:10, 246:2, 262:2, 265:22, 267:3, 269:6, 269:11, 275:13 timeframe 19:12 times 149:8, 149:9, 149:11, 152:1, 160:6, 200:22, 259:6 titer 150:11 titers 147:11, 147:18, 259:5, 260:11 title 7:20, 7:21, 16:12, 16:13, 57:2, 143:8, 201:5, 250:7 titled 11:18, 35:7, 69:7, 75:13, 89:6 tm 147:21, 149:3, 152:3, 261:1 today 8:11, 8:14, 9:2, 9:8, 11:6, 11:12, 14:1, 15:4, 22:2, 90:18, 94:12, 122:10, 169:10, 173:17, 241:22, 243:16, 254:17, 257:15, 257:20, 269:21	together 23:22, 25:8, 160:3, 161:19, 178:22, 179:2, 179:5, 179:7, 201:2, 203:16, 204:4, 211:2, 220:15, 245:11, 258:17, 259:10, 265:10 told 50:8 took 8:8, 79:9, 129:11, 247:3, 272:15, 272:16 tool 95:1, 96:3, 96:9, 97:8, 98:8, 114:3, 114:13, 114:14, 200:4, 202:1, 228:13, 228:20, 228:22, 230:3, 232:4 top 240:21 topic 119:15 towards 73:2, 117:21, 126:15, 219:1, 219:18 trademark 1:1 traditional 44:3, 44:18, 63:3, 187:11, 195:19 transcribe 10:7, 146:14 transcribed 6:13, 77:17, 83:9, 94:4, 146:6, 146:11, 146:16, 188:5 transcribing 10:1	transcript 5:8, 6:2, 18:3, 33:8, 35:2, 70:3, 75:9, 88:14, 102:11, 122:17, 142:3, 198:9, 209:2, 239:5 transcripts 188:18 transfection 34:9, 46:3 transfer 44:22, 73:13 transferred 73:16 translatable 191:5, 191:11 translated 77:18, 77:22, 146:7, 188:5, 188:11, 190:2, 240:16 translation 204:16, 205:2, 205:6, 205:7, 207:8, 207:16 translational 89:9, 94:20, 251:21 transmembrane 148:2, 148:10, 150:4, 152:15, 259:14, 259:16, 260:5, 261:2 transmit 21:13 treat 5:17, 75:14 trial 1:3, 8:5, 10:19, 118:18, 196:9, 274:10 trials 79:10, 274:8, 274:12 triangle 147:21
--	---	---	---

trick 66:21, 218:11 tries 126:15 trigger 93:18 triggered 268:2 true 72:18, 80:8, 143:18, 164:19, 167:3, 172:21, 227:19, 228:15, 273:16, 277:9 truncated 147:20, 148:10, 148:20, 149:4, 150:19, 151:7, 151:16, 259:22, 260:12, 261:13, 261:22, 262:21 truthfully 8:14 try 48:16, 49:16, 61:12, 84:1, 137:17, 164:5, 197:8, 231:1, 245:13, 265:10 trying 12:12, 17:19, 41:9, 55:18, 66:21, 67:3, 99:19, 110:19, 122:21, 149:22, 193:14, 206:14, 218:11, 232:7, 232:13, 232:20, 270:1 tuesday 17:6 tumor 241:5 turn 9:6, 16:1, 79:3, 79:4, 107:20, 125:18, 194:11, 197:21,	204:7 turning 247:3 turns 126:17 twice 147:15, 148:5, 148:6, 148:12, 149:16, 149:19 two 10:7, 10:18, 10:21, 11:17, 11:18, 29:13, 32:21, 68:21, 94:16, 96:13, 114:22, 122:5, 132:8, 136:17, 137:3, 137:13, 137:20, 139:4, 139:19, 149:9, 149:11, 151:15, 153:20, 167:14, 174:5, 180:17, 180:22, 199:22, 203:15, 252:16, 258:17, 258:22, 273:17, 275:9 type 24:10, 24:16, 25:1, 25:2, 25:14, 28:14, 48:22, 65:20, 76:19, 76:22, 103:15, 104:6, 116:12, 116:19, 154:22, 165:15, 187:14, 248:18, 252:8, 252:11, 252:15, 253:9, 253:12, 271:4, 271:18, 272:8, 272:9 types 25:13, 26:10, 29:14, 50:12, 58:7, 114:8, 114:11, 160:21, 223:16, 223:22,	224:11, 224:15, 225:10, 251:10, 260:2, 261:7, 270:14, 270:16, 272:6, 273:6, 274:19 typical 34:14, 186:22 typically 119:20, 161:1, 227:13, 241:3, 241:9 typing 166:13 <hr/> U <hr/> uh-hmm 9:14, 13:7, 17:3, 24:15, 67:7, 68:16, 70:7, 71:3, 79:19, 87:14, 89:14, 95:5, 103:2, 122:8, 181:7, 247:8, 247:11, 250:9 ultimately 63:17, 77:15, 78:4, 160:7, 203:19, 261:10 under 19:7, 24:7, 56:12, 57:2, 109:9, 109:16, 118:4, 125:22, 127:11, 132:14, 132:17, 136:2, 138:17, 146:9, 147:9, 172:19, 204:18, 221:7, 221:9, 221:16, 249:19 undergoes 170:15 understand 10:11, 10:17, 11:2, 11:5, 11:8, 11:11,	29:8, 34:3, 41:9, 51:20, 67:3, 110:19, 123:16, 137:11, 148:9, 159:1, 164:9, 182:2, 182:12, 185:9, 200:19, 208:7, 209:8, 210:14, 211:17, 238:4, 243:15, 243:17, 243:22, 257:5, 257:7, 270:1 understanding 53:5, 115:12, 115:18, 123:4, 123:20, 124:5, 124:13, 124:17, 125:2, 125:6, 125:15, 140:15, 153:21, 154:9, 155:16, 182:6, 213:15, 213:17, 213:20, 216:1, 216:4, 217:16, 217:19, 218:6, 219:5, 220:8, 235:22, 236:4, 256:10 understood 10:15, 58:22 undertake 160:13 undue 246:17 unfeasible 94:8 unfortunately 84:20 unique 133:20 united 1:1 universal 26:13 university 7:18, 18:10, 84:6, 127:6
--	--	--	---

<p>unless 9:12, 45:17, 50:13 unlike 187:16, 187:22 unlikely 229:5 unpublished 55:6, 84:7 unstable 87:17, 87:20, 90:21, 97:6 unsure 214:14, 214:20 until 57:22, 80:12, 81:10, 82:2, 131:21, 191:22, 229:20 untranslated 135:3 update 22:5 updated 18:15, 18:17, 18:20, 22:3, 22:14, 23:6 uptake 191:19, 192:17, 193:1 use 24:10, 24:17, 28:15, 30:9, 30:10, 34:2, 38:3, 46:8, 46:19, 53:22, 54:4, 55:11, 65:5, 85:3, 86:12, 94:8, 100:3, 104:4, 104:11, 114:3, 114:13, 114:14, 120:3, 120:5, 120:8, 136:17, 137:3, 160:1, 177:16, 178:15, 182:5, 197:3, 201:8, 203:8,</p>	<p>212:13, 216:17, 230:15, 230:17, 231:5, 231:10, 232:2, 232:7, 232:13, 234:22, 246:21, 271:18 useful 131:12 uses 38:14, 227:16, 231:20 using 23:10, 24:19, 25:2, 32:8, 33:10, 47:3, 47:14, 48:2, 54:8, 55:2, 56:3, 56:14, 65:16, 66:1, 84:15, 96:16, 104:16, 105:9, 111:4, 111:19, 117:2, 130:8, 130:10, 189:3, 190:5, 190:13, 207:11, 216:19, 218:4, 218:5, 231:12, 231:14, 233:3, 233:19, 235:5, 251:4, 268:6, 270:4, 271:9 usually 180:17, 241:1, 258:18 utilize 188:7, 188:13 utr 204:19, 204:22, 205:12 uw 18:7</p>	<p>96:17, 98:9, 98:11, 98:16, 99:2, 195:19 vaccinia 250:2 vaccinologist 21:22 vaccinology 195:18, 201:4, 201:19 vague 190:9, 190:16, 224:8, 233:22 valid 69:17, 100:15 validate 47:20, 52:2 validated 145:12 validates 48:5 validating 78:22 value 227:14 variability 19:9 variable 120:14, 253:6, 275:6 variables 28:7, 120:7, 137:7, 137:13 variant 20:6, 20:12, 21:3, 21:8, 31:13 variants 15:11, 20:7 variation 117:20 variations 28:6, 119:2 variety 28:16, 194:4, 244:2 various 58:7, 66:1,</p>	<p>100:10, 129:9, 160:5, 193:19, 200:21, 200:22, 206:7, 226:9, 274:12 vector 28:20, 89:8, 187:16, 187:22, 195:20, 196:3, 247:16, 247:19, 247:20, 248:6, 249:1, 249:12 vehicle 192:5, 192:11 vennema 247:10, 247:12, 247:16, 249:18 vennema's 248:5 verbal 10:2 verified 257:2 version 18:13, 18:16, 85:11, 149:5, 259:16, 259:22, 260:12, 261:13, 262:21 versions 206:7, 206:9, 206:16, 206:22 versus 151:16, 189:11, 273:15 vertebrate 236:17, 236:18, 237:8, 237:9, 238:18 view 16:20, 79:20, 98:10, 158:4, 243:20, 244:6, 244:7 vinny 4:12 viral 19:10, 20:5,</p>
--	--	--	---

28:19, 38:16, 47:14, 58:11, 118:6, 133:13, 144:9, 187:16, 187:22, 195:20, 196:2, 241:5, 241:15, 247:16, 247:19, 247:20, 248:6, 249:1, 249:12, 256:8, 257:10 virus 38:14, 57:9, 57:12, 57:15, 57:22, 60:15, 71:14, 118:15, 186:15, 186:22, 240:19, 250:2 viruses 27:8 vitae 5:10 vitro 46:2, 52:3, 94:4 vivo 45:16, 45:21, 49:9, 49:18, 90:11, 94:21, 95:15, 191:17, 194:1, 198:22, 217:9, 219:2, 232:9, 240:16 voice 171:12, 172:4 <hr/> W <hr/> walk 166:3, 166:4, 170:8 walked 170:7 wane 126:19 want 9:7, 28:4, 29:14, 30:7, 30:8, 30:10, 	44:10, 44:16, 49:15, 51:20, 53:21, 59:18, 74:5, 96:22, 97:1, 98:1, 98:2, 98:3, 98:21, 100:1, 107:9, 107:21, 114:12, 117:12, 117:16, 120:17, 121:14, 136:21, 144:3, 144:13, 150:8, 151:15, 152:4, 152:8, 154:16, 158:6, 163:8, 164:9, 164:12, 169:14, 172:19, 175:4, 180:5, 185:9, 197:8, 202:18, 202:20, 212:4, 215:21, 215:22, 217:16, 220:7, 223:2, 232:21, 235:2, 235:8, 235:9, 242:21, 243:1, 245:1, 245:15, 246:2, 246:6, 247:6, 254:20, 257:11, 257:13, 265:13, 269:5, 271:16 wanted 82:12, 240:5, 252:13, 253:4 wanting 226:17, 228:7, 234:22 washington 3:17, 7:16, 7:19, 8:1, 18:11, 19:1, 84:6, 127:6 waving 80:4, 82:7 wax 126:19 way 18:21, 53:21, 	66:14, 83:8, 113:19, 121:2, 124:4, 126:13, 129:12, 139:13, 170:14, 185:10, 201:12, 219:3, 220:13, 233:11, 244:3, 263:4, 274:1, 277:26 ways 86:10, 203:6, 271:1 we'll 9:15, 64:19, 87:4, 139:13, 209:4, 209:5, 215:22, 276:1 we're 25:10, 25:12, 26:11, 27:5, 27:10, 29:16, 31:10, 46:15, 64:11, 81:3, 81:21, 90:13, 100:6, 100:9, 103:10, 116:21, 117:22, 119:15, 138:10, 138:14, 148:14, 151:14, 160:4, 174:15, 175:2, 175:4, 193:4, 204:10, 209:6, 210:20, 211:9, 211:10, 226:8, 242:22, 270:11 we've 75:3, 94:11, 112:18, 148:1, 148:5, 158:4, 241:22 web 30:18, 31:22 website 18:8, 18:11, 18:16, 19:8 wednesday 17:6, 17:10 	weeks 76:5 weissman 55:10, 55:22, 84:5, 89:15, 89:20, 93:3, 97:4, 130:15, 190:21, 191:13 went 14:13, 170:6 weren't 252:20 whatever 22:17, 23:7, 29:2, 30:9, 56:2, 183:4, 271:13 whatsoever 8:21, 219:5, 236:4 wheelhouse 218:15 whenever 179:8 whereas 189:13 wherein 153:12 whereof 277:29 whether 12:16, 12:19, 13:16, 21:5, 29:6, 29:20, 30:14, 43:19, 45:19, 46:3, 46:5, 48:21, 64:20, 67:8, 81:4, 93:1, 109:1, 116:11, 116:18, 119:10, 120:17, 125:3, 125:14, 131:6, 137:13, 152:20, 155:19, 178:19, 214:5, 214:13, 214:14, 214:19, 214:20, 215:3,
---	--	--	--

215:4, 215:8, 215:11, 215:18, 215:19, 216:5, 216:6, 216:10, 216:14, 217:20, 218:8, 218:12, 219:4, 219:5, 220:7, 227:22, 228:8, 231:22, 232:6, 248:20, 253:19, 263:8, 266:17, 270:16 white 132:6 whole 195:3, 223:4, 224:11, 239:1, 245:6, 260:21, 260:22, 262:5, 273:13 wide 23:13 williams 3:15 willing 13:16 wilmer 2:4, 4:6, 277:18 withdrawing 177:4 within 36:8, 57:4, 76:4, 161:17, 195:3, 200:20, 215:12, 218:16, 250:17, 277:3 without 43:6, 92:22, 117:15, 133:6, 135:10, 169:21, 172:16, 173:10, 173:17, 180:4, 217:21, 218:4, 222:16, 246:17, 261:6 witness 75:5, 111:22,	137:8, 217:3, 254:6, 276:7, 277:5, 277:10, 277:29 word 88:18, 98:11, 115:6, 143:2, 165:8, 240:2 words 153:20, 154:1, 161:19, 163:1, 163:9, 163:10, 163:11, 165:17, 166:17, 167:12, 169:6, 169:19, 170:18, 260:3, 265:5 work 23:16, 23:18, 23:20, 34:15, 42:19, 72:21, 104:7, 116:14, 116:17, 120:6, 126:21, 129:9, 130:14, 131:9, 142:18, 161:8, 175:12, 177:16, 179:6, 195:18, 206:3, 213:6, 229:4, 229:5, 229:7, 229:8, 230:5, 269:12, 270:8 worked 56:9, 56:10 working 29:6, 31:6, 33:1, 33:19, 47:6, 84:22, 90:20, 132:8, 174:10, 174:14, 196:6, 229:13, 269:15 works 72:19, 76:19, 137:18 worldwide 19:8, 57:6	wouldn't 22:6, 36:13, 45:16, 49:5, 50:4, 121:2, 121:8, 128:11, 146:19, 231:16, 239:14, 243:7 write 82:17, 82:21, 85:8, 104:8, 107:17, 159:20, 160:2, 161:18, 162:10, 162:15, 162:17, 163:9, 164:22, 165:8, 179:1, 179:3 writing 107:14, 160:5, 161:16, 165:9, 166:17, 172:13, 172:14, 173:8, 174:16, 174:19, 174:21, 179:8 written 75:17, 77:9, 107:10, 167:5, 167:6, 167:10, 167:21, 168:3, 168:7, 168:16, 168:21, 199:1, 202:22, 274:6 wrong 103:10, 204:11 wrote 52:17, 84:10, 85:10, 159:17, 162:12, 163:10, 163:11, 165:2, 165:5, 171:9, 172:2, 186:10 <hr/> x <hr/> xun 3:14 <hr/> y <hr/> yang 244:7	yeah 11:7, 16:4, 16:8, 17:12, 42:6, 43:3, 43:5, 53:1, 56:11, 58:19, 60:1, 63:20, 69:12, 76:1, 78:13, 80:4, 80:10, 94:13, 101:16, 102:2, 109:19, 114:12, 124:16, 124:20, 125:1, 125:5, 125:16, 129:3, 131:3, 133:16, 134:5, 143:8, 146:2, 159:4, 160:16, 173:14, 175:10, 180:21, 202:14, 205:14, 210:19, 224:5, 247:19, 255:4 year 16:16, 82:13, 258:10 years 23:20, 26:9, 55:19, 76:20, 79:14, 80:3, 80:16, 81:18, 81:20, 82:3, 82:8, 200:9, 201:9, 203:2, 203:18, 203:22 yields 89:7 york 3:9 young 118:17 yourself 121:11, 162:15, 212:5 yup 251:22 <hr/> z <hr/> zealand 132:6
---	---	--	---

zika 46:20, 47:14, 48:2, 48:9, 50:14, 126:18, 127:2, 127:3 zone 203:20 zwitterionic 108:20, 109:1, 117:3 <hr/> \$ <hr/> \$320 9:5 <hr/> 0 <hr/> 0.5 153:15 00 254:4 01358 1:11 01359 1:14 02109 2:6, 4:8, 277:19 026640 182:9 03 254:4 04 254:9 07 1:22, 277:20 <hr/> 1 <hr/> 1 157:10 1,146 159:10 1,153 159:15 1,2 112:5 1,300 134:2 1.5 136:7, 136:10,	138:2, 140:3, 140:12, 226:4 10 75:6, 108:20, 117:3, 136:7, 136:10, 138:1, 140:1, 140:12, 183:6, 226:4 10,702,600 1:12, 11:3 10,933,127 1:15, 11:9 1001 6:3, 6:4, 122:15 1009 6:5, 208:21, 209:1 1010 6:6, 239:4, 239:7 10166 3:9 102 6:9 1022 6:7, 88:13, 88:16, 94:4 1031 6:8, 70:2, 70:4 104 170:22 1098 5:10, 18:2, 18:5 1099 5:11, 35:1, 35:4, 72:8, 251:21 11 64:18, 68:15, 68:19, 69:4, 70:6 1100 5:16, 75:7, 75:12, 202:12 1101 5:20, 142:1,	142:5, 257:13, 262:11 12 72:21, 73:12, 157:10 122 6:3, 6:4 127 6:3, 8:18, 11:12, 12:21, 122:6, 122:14, 122:15, 123:17, 124:18, 125:3, 153:3, 153:4, 158:12, 158:18, 158:22, 159:6, 159:9, 159:17, 161:22, 162:11, 162:14, 163:20, 164:3, 164:10, 164:16, 165:1, 165:14, 168:3, 173:21, 174:8, 175:8, 175:12, 176:8, 180:20, 181:2, 211:3, 211:4, 215:14, 235:13, 243:11, 244:16, 244:20, 245:14, 254:17, 255:16 13 72:21 1358 10:21, 11:2, 12:3, 159:2 1359 10:22, 11:8, 11:22, 158:21 14 72:22 142 5:20 14605 107:21, 117:21 15 72:22, 73:12, 153:15, 157:10,	180:16, 240:9, 243:13, 277:31 18 5:10 19 22:20, 30:22, 31:8, 37:4, 57:5, 157:10, 239:21, 239:22, 240:1, 241:12, 251:2, 253:3, 253:14 198 6:10 1990 32:8, 32:10, 32:17, 32:18, 33:5, 34:1, 75:2, 90:19, 128:15, 128:21, 129:2, 129:4, 129:8, 129:11, 268:15, 269:16 1992 32:13, 268:17, 269:4 1998 32:18, 33:5 1b 108:1, 108:2, 108:3, 109:21, 111:2, 111:8, 111:21, 112:1, 112:7, 112:10, 112:15, 117:2, 149:2, 258:22 1c 113:8, 113:15, 113:16 <hr/> 2 <hr/> 2 208:18 20 136:2, 138:15, 139:3, 153:13, 186:11 200 3:8
--	--	---	---

2000 129:12 2002 125:20 20024 3:17 2003 40:14, 44:1, 60:22, 61:4, 61:12, 61:16 2004 60:22, 73:22 2005 60:22, 61:4, 61:12, 61:16 2008 73:22, 89:17, 95:4, 95:6, 96:1, 99:9, 191:9, 200:9 2009 69:14, 70:5, 70:9, 70:10, 71:5, 71:11, 71:19 2012 103:8, 103:9, 103:11, 106:18, 107:16 2013 182:9, 213:1 2014 79:21 2015 32:3, 32:5, 34:11, 34:18, 58:18, 59:7, 62:11, 62:18, 62:22, 79:21, 123:3, 123:15, 126:5, 126:11, 127:1, 129:12, 129:19, 130:12, 130:18, 131:19, 141:11, 143:18, 143:19, 152:11, 193:10, 193:18, 193:19, 194:14,	194:19, 195:22, 196:10, 196:18, 197:15, 197:18, 205:22, 207:14, 243:14, 252:21, 253:7, 258:11, 258:16, 262:4 2016 74:1, 80:1, 80:13, 80:20, 82:2, 82:15, 84:6, 203:20 2017 81:1, 81:10, 82:2, 82:15, 84:9, 84:19, 127:7, 203:20 2018 81:1, 81:10, 199:3, 200:10, 201:16, 201:17 2019 33:1, 57:4, 57:5, 57:10, 269:19 202 3:18 2020 16:17, 31:12, 36:22, 37:2, 37:3, 39:15, 39:18, 42:15, 46:15, 46:18, 57:13, 57:14, 64:16, 68:2, 70:6, 72:8, 122:20, 131:21, 252:16, 253:2, 253:6, 253:7 2021 6:9, 12:10, 12:11, 12:13, 102:7, 102:10, 104:13, 104:21, 108:19, 109:6, 110:11, 112:9, 112:13 2022 17:20, 17:22,	75:22, 79:18, 80:7, 80:17, 90:22, 91:8, 91:11, 91:21, 92:7, 92:17, 99:12, 103:6, 103:22, 104:1, 104:6, 107:11, 107:15, 109:6 2023 1:11, 1:14, 10:21, 10:22, 11:2, 11:8, 13:15, 17:20 2024 1:21, 277:20, 277:30 2026 277:31 2027 6:10, 198:1, 198:2, 198:8, 198:10 2029 249:22 208 244:15 209 6:5 212 3:10, 136:2, 137:22, 138:8, 138:9, 138:21, 139:15 213 131:22 214 132:1 2195 12:3 2199 11:22, 12:5, 12:6, 158:9, 158:11 22 123:3, 123:15, 132:2, 208:18, 210:6, 211:6,	220:3 23 75:6, 132:1, 132:2, 132:3, 132:5, 132:15, 133:4, 134:6, 134:9, 134:12, 134:14, 135:13, 135:17, 136:17, 137:3, 137:20, 139:7, 141:6, 220:3 239 6:6 24 75:22, 132:1, 132:4, 135:13, 135:17, 136:17, 137:3, 137:20, 139:7, 141:6, 182:1, 220:4, 254:9 25 153:14 254 5:5 261 199:8 262 204:8, 204:9, 204:14 263 205:17 269 247:4, 249:20 27 110:18 277 1:25 28 122:20 <hr/> 3 <hr/> 3 204:19, 204:22, 205:12, 247:1 30 76:20, 174:2,
--	---	--	--

174:8, 174:18, 175:1, 175:7 318 3:10 340 212:2, 212:3, 220:18, 221:2, 221:10, 221:15 342 236:13, 237:1, 237:3 35 5:11 36 247:1 38 183:17, 184:2 38.5 136:7, 136:12, 138:2, 140:7, 140:12, 226:4 39 184:17 3c 181:8 3rd 277:30 <hr/> 4 <hr/> 4 254:4, 254:9, 275:20, 276:3, 276:8, 277:21 40 75:6, 109:7, 109:22, 110:12, 117:5 434 3:18 44 208:18 458 159:13, 159:14, 174:7 464 159:6 465 159:7, 159:18,	174:8 47 136:3, 275:20 48 112:9, 112:10, 117:7 <hr/> 5 <hr/> 5 134:13, 134:14, 134:15, 134:18, 134:19, 135:1, 135:2, 153:14, 204:19, 204:22, 205:12, 205:18, 206:1, 206:7, 206:16, 207:2 50 136:7, 136:8, 136:9, 138:1, 139:16, 140:12, 186:6, 186:8, 186:10, 226:4 5000 3:18 51 275:20, 276:3 52 247:1 526 2:7, 4:9 53 276:3, 276:8, 277:21 547017 1:24 55 153:14 5th 37:2 <hr/> 6 <hr/> 60 2:5, 4:7, 132:14, 132:17, 153:13, 277:19 600 6:4, 8:19,	11:6, 12:21, 122:6, 122:13, 122:15, 122:18, 123:5, 123:13, 123:16, 124:18, 125:3, 125:18, 127:11, 128:12, 129:1, 131:13, 131:19, 140:16, 158:13, 158:19, 159:12, 162:5, 162:11, 164:19, 167:3, 174:4, 174:7, 175:9, 175:12, 180:20, 215:14, 235:13, 243:11, 245:14 6000 2:7, 3:10 610 246:19, 247:7, 247:9 617 2:7, 4:9 6243 4:9 680 3:16 <hr/> 7 <hr/> 70 6:8 72 194:11, 197:21, 198:15, 208:13 75 5:16 7th 31:11, 57:14 <hr/> 8 <hr/> 88 6:7 <hr/> 9 <hr/> 9 1:22, 277:20 90 129:17	9450 7:15 98 34:1
--	---	---	--