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Science, Between the Lines: Rosalind Franklin

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Scientist, Between the Lines: Rosalind Franklin

An Experimental Literary Approach to Understanding Scientific Literature and Lifestyle in Context with Human Tendencies

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Structure is a common theme in Rosalind Franklin's research work. Her earliest research focused on the structure of coal, shifted focus to DNA, and then to RNA in the Tobacco Mosaic Virus. Based off of the physical and chemical makeup, Rosalind Franklin sought to understand the function of these molecules, and how they carried out processes such as reproduction or changes in configuration. She was intrigued by the existence of a deliberate order in life, a design that is specific in its purpose, and allows for efficient processes. For example, the layering of coal micelles was found to be more durable when arranged uniformly.

Coal

Franklin's investigation of coals at British Coal Utilisation Research Association (B.C.U.R.A.) is probably not well known outside of physical chemistry, but her findings have been adopted as fundamental in carbon studies. At B.C.U.R.A., Franklin and director Dr. D. H. Bangham subjected coals to gradual heating in order to determine that the thermal expansion coefficient is proportional to temperature (Bangham & Franklin 1946). Due to the differentiation in structure of the molecules, graphitizing or bituminous coals were found to behave differently in response to temperature changes (Bangham and Franklin 1946). But more importantly, this research was a milestone because it was the first time that carbon had been studied at high temperatures, specifically reaching 3000°C, defined the resiliency of coals in adverse temperatures (Harris 2001).

In response to the demand for graphitising carbons, which were used in wartime nuclear research, Franklin focused on calculating densities in substances such as helium, methanol, water and n-hexane (Harris 2001). She found the densities of the coals were dependent on the surface area, which increased with the amount of pores penetrable by the liquids adsorbed into the structure (Franklin 1948). More dense carbons permitted less water penetration due to closely packed carbon micelles, and thus explained why some coals were less permeable to liquids of differing molecular sizes (Franklin 1948). When solute molecules are unable to pass into the pores, the coal cannot react with the solute. Thus carbons with increased densities had decreased reactivity (Harris 2001).

Carbon and x-ray crystallography

Franklin continued researching carbons at the Laboratoire Central des Services Chimiques de l'Etat, located in Paris. Here, she encountered, through her friend Adrienne Weill, well-established x-ray crystallography technician Jacques Mering. Mering became Franklin's research assistant and introduced her to a method that would further enable her to determine molecular structure of coal by-products and also would be an essential skill in her future research career (Franklin 1950). Franklin, via x-ray crystallography, was able to compare the diameter of crystallizing carbon versus amorphous carbon. She determined that non-organized carbons had larger diameters in comparison to graphitizing carbons, because graphitizing carbons are more tightly packed in uniform layers (Franklin 1951). Franklin called these disorganized carbons 'non-graphitizing': carbons whose structures at high temperatures would, instead of arranging into clean layers, take on a non-patterned 3-dimensional structure (Franklin 1951). The distinction was a major discovery in the field, for research and commercial use. Graphitizing carbons are preferred for industrial use due to their structurally sound nature compared to amorphous carbons.

DNA research

Franklin's fundamental work in carbon structures employing x-ray crystallography techniques broadened her opportunities for funded research. In addition to her publications regarding structural aspects of coals and carbon structure, Franklin had acquired an applicable skill set. Her mastery of the x-ray crystallography made her a valuable contributor to research teams in biophysical and biochemical fields, a first for someone who spent the majority of her career in carbonized structures. Thus, she was recruited to research DNA in London at King's College. Joining Maurice Wilkins' team, Franklin focused on the dehydrated "A-form" DNA.

X-ray crystallographic methods for large molecules such as DNA rely on calculations like the Cylindrical Patterson function and Bissell Function, which concern the appearance and displacement of layer lines. By studying sodium thymonucleate (the sodium salt of nucleic acid extracted from calf thymus) using X-ray crystallography, Franklin and Ph. D. student Ryan Gosling, found that the structure of DNA varied at different humidities, and that the transition from A-form to B-form is reversible. Furthermore, they determined that the structure of DNA is most stable at 75% relative humidity. X-ray photographs of this form prompted Franklin and

Gosling to hypothesize "while the x-ray evidence cannot, at present, be taken as direct proof that the structure is helical, other conditions discussed below make the existence of a helical structure highly probable" (Franklin & Gosling 1953).

At the same time that Wilkins, Franklin, and Gosling were examining DNA structure through x-ray crystallography, another group, comprised of James Watson and Francis Crick were pursuing the same question using model building techniques. The calculations from the Patterson function coincided with Watson and Crick's research, which was published based on many of the same research findings. On page 741 of the journal *Nature,* Franklin and Gosling note "Thus our general ideas are not inconsistent with the model proposed by Watson and Crick in the preceding communication" (Franklin & Gosling 1953). Watson and Crick's conclusions were published just a page before Wilkins' paper titled "Molecular Structure of Deoxypentose Nucleic Acids," which was just before Franklin and Gosling's "Molecular Configuration in Sodium Thymonucleate."

Wilkins, who as Franklin's colleague, often shared equipment and supplies, discusses X-ray crystallographic measurements of DNA. He uses one of his own plates as a reference, but mentions that Franklin and Gosling's photograph in the following publication is "exceptional" (Wilkins 1953). Based on Franklin's 'photograph 51,' Watson and Crick solidified their theoretical structure by placing the bases on the inside of the helix and the phosphates on the outside of the strands(Watson and Crick 1953). But, without physical data of their own, they had to rely on the research of fellow scientists, such as Franklin and Wilkins. Watson and Crick conclude "So far as we can tell, [our proposed structure] is roughly compatible with the experimental data, but it must be regarded as unproved until it has been checked against more exact results" (Watson and Crick 1953).

Tobacco Mosaic Virus RNA research

Upon leaving King's College, Franklin took a post with esteemed scientist John Bernal at Birkbeck College, where she began exploring the structure of Tobacco Mosaic Virus (TMV). There was great interest in this problem among molecular biologists because understanding the structure of this pathogen could elucidate how viruses compromise their hosts and facilitate transmission of disease (Creager and Morgan 2008).

By the time Franklin initiated her investigation of TMV, it had been established that the virus was composed of protein and nucleic acid. Her challenge was to determine the arrangement of the protein and nucleic acid molecules within the viral particles. Franklin, along with postdoctoral research fellow Aaron Klug, once again applied x-ray crystallographic techniques to analyze different strains of TMV. By using X-ray crystallography, Franklin was able to conclude that TMV RNA helices were directly associated with the proteins, creating a hollow cylinder-shaped molecule with protein subunits bonded to the outside of the RNA (Franklin 1955).

Rosalind Franklin worked tirelessly to attain inarguable evidence. Evidence, meaning unbiased and efficient material. Perhaps she could not make mistakes, being a woman in an era where female scientists were not only rare but often not taken seriously. Franklin could not afford any missteps. With her perfectionist attitude, being on par or better than any male or well-established peer seemed to come naturally. Her success was not solely attributed to her attitude, though. If Franklin worked only with the burning desire to prove her bosses wrong, she may not have had enough fire to completely immerse herself year after year in similar types of research. To understand her drive, readers need to understand Franklin as a person, rather than as the omniscient structure-definer.

Franklin's research was fueled by her own interest. She pushed herself into studies by choice, so she could contribute to the field. Franklin was interested in her research; she wanted to learn, to see outcomes, to hypothesize. Even from a young age, Brenda Maddox, author of "Rosalind Franklin: The Dark Lady of DNA" shows Frankin as an inquisitive and diligent woman. In a letter to her father arguing about faith and reasoning, Rosalind Franklin states "But science and everyday life cannot and should not be separated. Science, for me, gives a partial explanation of life...it is based on fact, experience and experiment" (Maddox 61).

In the literature review, a partial explanation of Franklin's life was attained. The following section is a creative attempt to form a more thorough understanding of Rosalind Franklin through a series of related vignettes. The sequence of short stories written in the following section are not true to one format, but attempt to include Franklin's thoughts as she is

engaging in research, as well as how science has influenced her thinking outside of the laboratory. The vignettes of her life are intended to re-humanize Franklin as a scientist, through her thoughts, within her research, and outside of the lab as well.

"Rosalind."

I look into my mother's eyes. She's not kidding, There's no use arguing when she can't understand my point. But I know I am right.

"Mother, I know you think this isn't the best choice for me. I know you'd rather have me stay at home until I can start a family, but frankly, I see no use in that."

"Rosalind, I don't think now is the right time for you to go to University. Your older brother hasn't earned his degree yet. Couldn't you wait until he returns?"

"So you suggest I wait here until there are no more wars?"

"Rosalind, that's not what I mean."

"Then I should go! I am sure that if I study with all my intent, I can do this."

"I believe you. Your grades give merit to that statement. But your brothers will most likely get involved in the conflict, and you'll be safe in the classroom studying new chemicals they're going to be putting in cheese."

"That's ridiculous! Completely, just--not logical. Mother, you know I have all the respect in the world for my brothers. They are my family! I've grown with them!"

"But what you want to do, essentially, is leap into something unknown. You'd rather leave here when tensions are high. Your father won't appreciate it--That you won't be directly affecting the war effort."

"How would you know? And just because I'm not a man doesn't mean I won't do my part. I can take care of myself!"

"Rosalind. I know that."

"Then why do you doubt my abilities? I can become a professional scientist."

"Where would you go? And are you going to pay for it?"

"I'm sure I can get scholarship money. Maybe I'll go to Oxford, or Cambridge. I'll apply to Newnham College. They accept girls."

“The world isn’t like that, Ros. Women are expected to knit or nurse. And that’s it.”

“Well, the world can change, can’t it? See, this is why I’ll take math and physics over social sciences. Numbers and results don’t have to fight in the war or stay home and knit. There is no use arguing with facts, if they are right. I’m certain academic scientists understand that.”

“Yes, what you say makes sense, but I doubt it. Talk to your father when he’s back, if this isn’t another one of your passing phases.”

“Mum! What don’t you understand? This is not a phase! This is not a passing...cloud. It's not me choosing a color for a skirt! This is my future, Mum! This is me doing what I love! It is not fair, not to me, not to Father, not to my brothers. And you know that. Why should I not be able to study?”

“Listen! Rosalind, you’re getting angry again. I know it isn’t fair. I think it’s about time you go into something larger than yourself. I believe you can go to college. I admit, to see you succeed in academia would impress us all. But the probabilities of finding work are so slim.”

“Mum, you’re contradicting yourself. Do you oppose my plans, or do you support them?”

“Ros, the Franklin family is incredibly influential. You must carry the name with certainty that it will not be tainted. The community knows us and as much as I want to see you head of a research facility, you’ll have to talk to Ellis.”

“This isn’t much help, Mum. But last time I brought it up to Father, he kept talking about the family’s reputation and our ‘regal’ genealogy. But I know that this whole thing isn’t hopeless. I’m going to study, I am. I don’t want an office job. I don’t want to be here forever.”

“Alright, Ros. Alright.”

It has just crossed my mind that I may have hurt Mother.

She’s been a secretary at our family’s bank business ever since she married Father. She doesn’t travel much, and doesn’t see the world as a wonderous place. Sometimes I wonder what she must think about when she’s sorting paperwork, unless her mind is completely consumed by the act of segregating papers by name or status, she must become bored with her work?

When I am working, I don't consider it any different from the rest of my life. It is my life; my day runs fluidly into my arrival at the lab and even when I'm not physically there, I still wonder about the results.

The act of examining an x-ray photograph begins with picking it up in both hands. The pattern is generally arranged with lines around a central axis. The length of the lines, as well as their direction and spacing, are the first things you should notice.

I have examined enough of these where the act has become almost automatic, in a way where I'll finish the initial markings and almost wish I was learning how to use the contraption again. The first few weeks were challenging, but I was immersed in the steps of x-ray crystallography. I thought I could test all of the substances labelled with dates from months back sitting on Jacques Mering's lab shelves, but he gladly gave me permission to test coals right away. Every mistake I made, he would laugh, even if I had wasted a day's work. He always told me I'd never make the same mistake, but make hundreds of new ones.

I have only been able to sharpen the focus in the practice of using the x-ray technology. There is no reason to worry about the quality if I am aware of all of my actions. But I've repeated the mechanical process so many times, sometimes I find myself working by rote.

If you have a cross in the diagram, it indicates helical structure. Thus, we can measure the spacing between the bases and determine what molecules can fit between the lines.

Phosphates contain negatively charged oxygen species, which push any positively charged species around to the other side of the molecule. So it must have a rigid structure. But is this the same in the hydrated form? Does the oxygen bind to the hydrogen, creating a less-polar molecule? Depending on how many phosphate molecules I have, I can fit a limited amount of molecules associated with oxygen onto the structure.

This exposure on this does not tell me enough.

It is frustrating to continually produce little new evidence. Once I begin to think that no substantial results are produced from this method, life turns dull.

But I expect something will be concluded if I keep altering the variations, little by little.

What am I doing?

I can look at plates on plates of DNA, RNA and never know whose war this ends, whose garden becomes immune to viruses. All of these gray lines and I still sit here with a pencil in my hand. Graphitic carbon. The graphite whose dust won't condense at the same rate in higher temperatures as a chunk of pencil lead.

Someone must find this useful in the future, that is, another researcher will be able to assume the structure I define to be true, and explore more deeply with the structure of DNA than I will dream. The beauty of research is that somebody had to start with the basics, but once the threshold statistics were established, the strongest heartwood is built, and you can branch out. You cannot debate the facts that hours of experimentation and calculations have proven to be true. Because it has been determined that viruses contain RNA, future researchers with a better understanding of RNA can prevent mosaic symptoms in gardens. Because humans and animals contain DNA--what am I doing?

I am laying the groundwork for understanding life, what's taken for granted the moment we awake, thinking about coffee, then putting our feet on the floor and remembering 'oh, I didn't learn anything new yesterday--' but what was it Jacques said two months ago? About boorish English? And me... "But at least you're not one to drag your feet," he said.

Ah, I should start another hydrated crystal.

That's right, I shall set up for the procedure again.

When I am working, nothing else exists. I'll roll up a chair and hunch over the plate, like an alien discovering a new planet. Except this is my planet and I know what I am looking for. The world is a vastly interesting place, but can always be explained. I want to define the smallest distinguishable parts of what we rely on to exist. For example, the bases in DNA code for all living creatures, though it is a language composed of a foreign alphabet. What I love to think is that I, or any willing scientist could decipher this 'foreign language'.

But I am in dire need of some soup.I feel like I've been ground into the floor.

When I would come home with a bad mark from school, Nanny would cheer me up with her grandma's French onion soup recipe.

This weather has got me down, lately, and I didn't get to set up another experiment before that dreadful social ball last Friday. I won't have results to expect tomorrow morning.

The recipe reads as follows:

"Start by boiling dried thyme, ground cumin and a pinch of cloves in cold water. While this is heating, peel ginger and slice into one-half centimeter slices. Place ginger into the boiling water with spices and allow to boil for one half hour to allow for full flavor production and nutrient release. Note: dried ginger may be used in place of fresh ginger, if not available."

Ginger, I don't have any of that. I suppose if there weren't a war happening, it might be possible to buy some at a specialty market upstream in London.

I'll just use extra cloves and some allspice. I suppose if I can't have the same flavor, I'll evolve the dish.

"Place butter into dutch oven to soften."

"Sauté onions with celery and carrots, then place entire mixture from pan into a bowl and purée."

I suppose that can be done with a potato masher.

If the onions are not cooked before being boiled in the broth, the result will be a rather pungent onion taste. The sautéing sweetens the onion first, by breaking down the oxidized sulfenic acid and sugars via heat instead of enzymatic action. The carrots are also cooked first to be softer when pureéing.

Have you ever tried to explain what an onion tastes like to a person who is fatally allergic? Or explaining blue to a blind person? You can only use similes and metaphors, which, of course, are never absolute. Say the blind man strongly dislikes taking baths, but you are trying to say that the color blue is like a warm bath. Then he'd assume that blue is not a satisfactory color. He'd rather have a black sky. Which, I guess is alright, but explaining things based off of experiences is largely based on individual preference.

The point, I guess I'm making to myself, is that the only truly reliable way to explain anything is by taking it piece by piece from differing perspectives. Many relevant perspectives. This is why researchers collaborate and publish work (besides job opportunities and job promotions). One test is great, but only really provides and explanation based on one example. Like I believe I can cook well, but I may be biased. I've been eating my cooking for years now! I'll have to get a second opinion.

I wonder what the next picture will look like after exposure. If it is anything like the last, it will have columns stretching out from the center. Sometimes I wonder if I just tilt the whole contraption like a bird in an air current, will the picture show something completely new? I am sure it can all be explained in the end. The molecules cannot possibly change, but a new perspective might give differing resonance. J'en sais quoi. The x-ray diffraction pattern will remain the same, how could I forget? But if it is not pointed directly at the plate, the rays would not be recorded. What a mess that could be!

I bet it has been done, either purposefully or not. Yes, someone must have missed the mark. I bet some strange things have been recorded in these crystal photographs. Or if a phantom happened to live in the building and sat under the ray for hours, would we get an unrecognizable pattern? Of course, it would have to be a still ghost, and a talented researcher! If someone had a ghost friend in a lab, I suppose it could be interesting to test the molecular structures of the undead. Or maybe it would exist in a transitional phase between human DNA and pure protein. What was that just now?

The paper lifted slightly. It settled right back down.

And a chill. Nobody died here, right? A soldier wouldn't wander up these stairs. There's nothing here for you.

Goosebumps. My, what a fright. I can't concentrate like this.

"Gosling?"

Rubbish. He's not in the office.

"Gosling? Gosling, are you here?"

Oh, I'd rather not work alone.

Calm down. It is day. And for goodness sake, Ros, the window is open.

"Do you need something, Dr. Franklin?"

"I, ah. I would like to review yesterday's calculations."

"Right. Just let me gather my notes."

"Sure. Do you mind if we use the office?"

"What, are you sick of the lab already."

"No. No, it's just chilly. I shall go shut the window and fetch my notebook. I'll meet you in two minutes."

"Will do."

Must be helical, layers 4-7 relatively quiet. Probably not longer than 20Å apart. Let me draw this again. I imagine if the symmetrical structure is held by hydrogen bonds, it must be separable by heat. This could coincide with the claim that the material included in RNA is reproducible via protein mediated translation. But at a certain heat the protein would unwind. What if it were heated in the crystalline form as opposed to paracrystalline? It is already known that virus proteins are denatured by increased temperatures, but perhaps I could include this as an examination of structure, in reaction to heat conditions. Then from the structure, the hint of function will appear. What the crystallographic data show is that the units are sufficiently similar to enable them to occupy structurally equivalent positions[1]. What if, when the strands are separated, I expose the crystal? Similar to this picture, the spacing would be regular and the lines of similar densities. But the cross would not form. Would the structure be stable enough to exist in separate strands? Probably not without an additional buffer. And then I might need to correct for the buffer. And what's not to say that it will find a way to bind back together, or if impure, the additional proteins may aid in reproducing the genes, as Watson and Crick are theorizing. No, I suppose single-stranded RNA may exist, but I have no evidence as of this moment.

"Franklin? I'm all set if you are?"

"Right!"

The younger scientists will get to know more about this than I will. I envy them for that, that at a certain age, I am expected to hold a higher position, one that does not necessarily allow me to get my hands in as much lab work as I would like.

Or at least, not with an adequate salary.[2]

Mother and Father have written to me, asking that I secure my quality of life. They are worried that if I keep up this low-paying research, I'll never be able to settle down. What a

[1] In a letter to the British virologist Norman W. Pirie, Franklin respectfully explains that proteins in TMV RNA are similar, or "structurally equivalent." (Maddox 252)

[2] In a letter to Bernal, Rosalind is venting about no "security of employment" despite her PhD and fourteen years of full-time research. (Maddox 264)

bore! If I settle down like them, I'll be stuck with repetitive office work and being friendly with old rich men. I'll be tired of my life within a week!

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It's a shame I've forgotten my rain slicker today. The rain is chilly and it stings through my fleece. It's not the first time I've left it at home against my instinct, though. I guess I can handle it. As a child, we'd play outside until our underwear were sticking to the insides of our legs and our cheeks tinted blue. What matters is the warmth you can generate from the inside.

It is necessary that a woman watch her shoes as she traverses King's brick walkway. Especially in wet conditions, with atmospheric precipitation settling above 0℃, the smooth surface of a clay brick loses static friction.

The use of an uncompromising woman's heel, which generally focuses more pressure around the small surface area, causes the wearer to rely on a less stable bond between her shoes and the slick walkway.

Oh, that's not right, is it? There is friction keeping the shoe in its place on the walkway. The uneven bricks are what causes the trouble. Erosion, because the earth and soil move due to cooling and expansion of the ground and water in the soil, cause the bricks to jut out in varying directions. Since the smaller surface area of a woman's shoe is connected to a body which balances momentarily on the other leg, then her body will be mobilized from equilibrium if the heel does not touch the ground at a 90° angle.

Likewise, a woman will be thrown off balance if she does not keep her head steady. This is a man's world, or so I've been told.

If she strikes from too small a viewpoint, and with not enough, she is in danger of slipping and falling.

It seems to me a danger only in thinking that way. If she is focused, her results will be no less than any other person.

The great doors to the laboratory open rather easily.

"Good Morning, Dr. Franklin, no bike today?"

"Good Morning, Dr. Wilkins. No, I decided to walk."

"Are you getting settled in your new place alright?"

“Yes, thank you. Though the weather leaves something to be desired. Today I shall be using the new French cameras. I expect that nobody disturbs them while in exposure, please.”

“Of course, I will let the graduate students know. But they are for all of us, too. I plan on using them tomorrow.”

“Thank you. My procedure should be completed by tomorrow morning.”

“Also, Dr. Randall wanted to check to be sure there are no errors in the setup.”

“I didn’t know Dr. Randall has used the French models before.”

“Well, he hasn’t. He does monitor our methodology, though.”

“Alright. If he could visit the lab before I begin the exposure process, please let him know. Otherwise, as you understand, the slightest change in light or shift in positioning alters the picture. He can stop by anytime before two o’clock.”

“Yes, of course, we’ve been familiar with the method for quite a bit longer than you have. Dr. Randall and I are very busy, these days, I can’t say when he’ll stop by.”

“Good, good for you. Then I expect you’ll knock before you enter.”

“Knock? Won’t your door be open?”

“No, I dislike distractions.”

“Would you leave it open today for Dr. Randall and I to check in?”

“Do you not trust my ability to set up the cameras?”

“That’s--That’s not it.”

“Then what? I am not a child! I can handle myself. I will talk to Dr. Randall myself and figure out a time that suits both of us.”

“What about his work? Wouldn’t you be a distraction for him?”

“Isn’t his door always open?”

“I--I am only trying to keep this lab formal.”

“Good, well so am I.”

“That’s--fine. But you can’t just barge in around here. You said so yourself!”

“I am well aware. But I need to talk to Dr. Randall.”

“Fine. But I will see the new cameras as well. Please inform me when you’re finished.”

“Then I’ll be off.”

“Right, well, I have the wet DNA, so I’ll be working with the other cameras.”

“I will be using the dehydrated form. If that does not suit you, I can use the wet DNA as well.”

“I can handle the dry form, Dr. Franklin.”

“I’ll inform you of my data after I set the crystals.” I say to Dr. Wilkins, for we have already been standing in the office area for more than five minutes. I want to get my work done and go back to France already. I would like to see Adrienne and some halfway decent weather.

I thought that maybe the 50th picture would reveal something extraordinary, but it isn’t clear yet. 99 hours ago, I set up for the 51st without high hopes. Luckily, lack of hope is not recorded with the data.

A quiet tapping on the concrete near my window ensures me that, indeed, it is still raining. It hasn’t stopped for a few days now, and the sun hasn’t shone for at least a week and a half.

I know that my skills in DNA crystallography are constantly being whetted, but I want out of this lab. Earlier, I heard that loud-mouth mention a “boorish Rosy”--me. And I hate it. A few weeks ago, a note on my door proposed that my lab is a “lounge.” I suppose I wouldn’t have to be stuck in here so much if I could just go to the cafeteria with the rest of the researchers!

No, my mother wasn’t right. This is just King’s college. This is just a homeland bellyache where men haven’t grown out of their treehouse boy’s club obsession. They are just pompous and lacking motivation.

Here, I’ve calculated the maximum number of Angstroms between the main length of the B molecule and its side chains.

This ‘Photo 51’ is so clear. DNA is helical. The calculations match up.

I don’t need to lose this photo. My wrists tingle whenever I see it.

I know Wilkins was very excited to see it.

It's a shame he hadn’t done it himself.

To think I’ll leave it behind puts me in the worst mood, because I, and Gosling, created and deciphered most of this.

I can't even justify being angry anymore. We know what DNA is made of--the whole world can know. It's beautiful.

I must write home before I get caught up in moving to Birkbeck. I have so much Tobacco Mosaic literature to read, I don't know where to start. But start I shall.

Let's put 51 back before anyone else tries to steal it.

Must be helices. Two strands? I can't be sure until after calculations. And if so, are the side groups attached via sugar, phosphate, or simple hydrogen bonds? Perhaps all of the bonds are not the same length.

Chargaff determined that the purines always bond to purines and pyrimidines always bond to pyrimidines.[3] So are those bonds the same length? Would they have to be to preserve this clean X pattern?

I shall have to see what Gosling thinks, he has a good mind.

Crick believes there to be an excessive amount of water in the molecule, but I disagree. We've determined that the max amount of moisture underwhelms his expectations. Agh! Crick and Watson with their structure building! It drives me mad when they make simple ignorant assumptions to base their ball-and-stick off of.

"I must take a break."

I'm getting all caught up in my apprehension.

Compared to France, which she adored, King's was strongly patriarchal, discriminatory, and dreary. Franklin was often mocked and excluded from the lounge and lunchroom, where only male faculty and staff were allowed to meet. The institution was set up based on a history of male-dominated laboratories, and many researchers were unable to accept that Franklin was an equal partner. She could not assimilate into a work environment that had no reason to accommodate a female staff member, and so she decided to continue her search elsewhere. On departure from King's, Franklin was asked to stop researching DNA so her co-researchers at King's could continue without competition. All her work was to become property of the institution, but it could not be helped.

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[3]Chargaff, E., 1950. "Chemical specificity of nucleic acids and mechanism of their enzymic degradation." Experientia 6, 201-209.

“Gosling, what do you think?”

“It’s a clear picture, that’s what I think.”

“Yes, I know that. But the calculations are pointing to only two strands of DNA, and the structure is more hydrated than I had originally thought.”

“Well, not necessarily, we haven’t corrected for the Van der Waal’s forces yet, but then again, how much of a difference can that make if the structure relies on hydrogen bonding?”

“No, you’re right, we haven’t finished the calculations.”

“Did you know that Wilkins is curious about the outcome?”

“Of course he is. He’s trying to decipher the same problem we are, only with a slightly different mindset.”

“Yes, but he asked to see our data so far. It is, after all, the same goal. I mean, we are in the same lab and all.”

“No, that man wishes I didn’t work here. It’s none of his business what I do or don’t do here.”

“He’s not that much of a predator! Well, maybe. I suppose he’s been here for years on his own, and now he has to share.”

“I don’t think he has to share, we inhabit the same space, is all. Now, the molecular weights. It is too much to have the phosphates bonded directly to the pyrimidines. We won’t have enough valence electrons to hold the ribbon together. If Wilkin’s disagrees, he’ll have to face the facts. I didn’t study this hard to worry whether or not a man dislikes me. Science is not a matter of whether or not you like who I am, there is no use in ruminating on feelings. The next step has to be taken.”

“Franklin, you know metaphors are not my strong suit. Just talk to Wilkins.”

“I’ll be out of here within the month, surely, or as soon as we can finish these calculations.”

“Alright. Yes, I do think we will have a double helix, central bonding. The purine bonding pattern? Do you suppose the base valency is similar?”

“I do, but not so uniform as Watson has hinted.”

“Of course. Franklin, you’ve got to wonder what made such a curious man work on DNA. He has a thousand ideas running through his mouth at once, I couldn’t keep up with him at dinner the other day.”

“Yes, I’ve met him before, he kept asking me about my past. It was unnerving, really, after seeing that he had forgotten basic chemistry.”

I do wonder why he wanted to research. Clearly, he is interested, but he doesn’t put in much effort of his own. He’s always snooping around here, playing buddy with Wilkins. I don’t like it. Oh, and his view on women. He’s always flirting. But he is a brilliant man, and he is entertaining. We do all have our strengths and weaknesses. Thank goodness Gosling is levelheaded.

“If I had that much going on, certainly I’d forget which hand is left and which is the right!”

Relatively levelheaded.

“Then you’d best know your chemistry better than your directions, Gosling, because we’ve got a ways to go!”

“I’ll be using the Patterson function for this layer, would you mind checking my work?”

Dear Mother and Father;

The latest update on my research is positive, and I thought I should let you know of the impact of my contributions. My Ph. D. student R. Gosling and I have been able to calculate the positioning of the molecules in the structure of DNA based off of my latest photograph. I hope it does not bother you that this substance, involved in the determination of traits, is made merely of proteins, sugars, and other molecules. It is a beautiful structure-- I can send you a copy of the publication, along with Crick and Watson’s, since they have taken the liberty to conclude their model building based off of my research. I’ll be working at Birkbeck come winter, determining the structure of a virus commonly found to create mosaic patterns on tobacco plants. This is made mainly of proteins as well, so I expect I will be able to handle the sudden switch in focus. I only regret leaving Gosling behind at King’s, because he has not finished his

Ph.D. yet, but I could not stand tensions with Wilkins anymore. It's a shame that such stubborn temperaments have a way of preventing scientific research.

We will speak soon;

Rosalind

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