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The GH-Method

Viscoelastic or Viscoplastic Glucose Theory (VGT #50): Studying the Role and Impact of the Viscosity Factors (Body Weight and Body Temperature) on Sensor Collected FPG (Symptom or Strain) Using a Stress-Strain Diagram from the Viscoelasticity/Plasticity Theory with Measured and Normalized Data Over 18 Months from 10/1/2020 to 3/27/2022 Based on the GH-Method: Math-Physical Medicine (No. 635)

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Note: Readers who want to get a quick overview can read the abstract, results, and graphs.

Abstract

The author was a professional engineer working in the fields of the space shuttle, naval battleships, nuclear power plant, computer hardware and software, artificial intelligence, and semiconductor chips. After retiring from his engineering job, he initiated his self-study and research on internal medicine with an emphasis on biomarker relationship exploration and disease prevention. Since 2010, he has utilized the academic disciplines learned from 7 different universities along with various work experiences to formulate his current medical research work over the past 13 years. One thing he has learned is that in engineering or medicine, people are frequently seeking answers, illustrations, or explanations for the relationships between the input variable (force on a structure or cause of a disease) and output variable (deformation on a structure or symptom of a disease). However, the relationships between input and output could be expressed with many different matrix formats of 1 x 1, 1 x n, m x 1, or m x n (m or n means different multiple variables). In addition to these mathematical complications, the output resulting from one or more inputs can also become an input of another output i.e., a symptom of certain causes can become a cause of another different symptom. This phenomenon is a complex scenario for a "chain effect". In fact, engineering and biomedical complications are fundamentally mathematical problems which correlate with many inherent physical laws or principles. Over the past 13 years, in his medical research work, he has encountered more than 100 different biomarkers with various relationships of causes (input variables) versus symptoms (output variables). For example, food and exercise influence both body weight (BW) and postprandial plasma glucose (PPG), while the pancreatic health state, BW, body temperature (BT), and sleep conditions affect the fasting plasma glucose (FPG) in the early morning. A persistent high glucose condition, including FPG and PPG, can result in diabetes. When diabetes combines with hypertension (high blood pressure) and hyperlipidemia (high blood lipids), they would likely cause various cardiovascular diseases (heart attacks) or strokes where blood pressure (BP) and lipids are tightly connected with food. Furthermore, obesity and diabetes are also linked with various cancers. These multiple sets of lifestyle and biomedical input versus disease output have been researched by the author using different tools he has learned from mathematics, physics, computer science, and engineering. Previously, he applied a signal processing technique to separate 19 components from the combined PPG wave. He identified the carbs/sugar intake amount and post-meal exercise as the two most important contributing factors to PPG formation. In addition, he also discovered more than 5 components causing FPG, including pancreatic beta cells health condition as the baseline, along with BW, sleep, and stress as additional influential forces. For his follow-up study, he identified the self-repairing capability of his pancreatic beta cells which has improved by quality and quantity of his insulin secretion by ~30% over the past 8 years. Based on these findings, he then applied the theory of elasticity from engineering to develop a linear elastic glucose theory (LEGT). This is to predict the PPG

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value with high prediction accuracy, using carbs/sugar grams and post-meal walking k-steps as two major input components of PPG formation. Based on his BW in the early morning, he predicted his FPG quite accurately. During the COVID pandemic period starting on 10/1/2020, he measured his BT in the early morning to monitor the health condition of his respiratory system. To date, with only 500+ days of data, he has already seen a high correlation coefficient of 80% existing between his FPG and BT. Hopefully, over time with additional collected BT data, he can further enhance his predicted FPG equation using BW and BT as the FPG's key influential components. Recently, he has applied the theories of viscoelasticity and viscoplasticity (VGT) to various biomedical problems and has written about 50 medical research papers. This VGT technique emphasizes the time-dependency characteristics of certain variables. In the medical field, most biomarkers are time-dependent since body organ cells are organic in nature and change constantly. Incidentally, VGT can generate a stress-strain curve or cause-symptom curve, which also indicates the relative energy created during the uploading (increasing influential force) and unloading (decreasing influential force) process over the timespan of a biomarker wave. In this article, he selected a dataset containing 3 biomarkers, sensor collected FPG, BW, and BT over the past 18 months from 10/1/2020 to 3/27/2022. He then utilized the above-mentioned concepts of the FPG formation and VGT research method to calculate the influences on S.FPG from BW and BT as influential forces. There are two models in this simple study: The first model is using normalized numbers of (measured BW / average BW) and (measured BT / average BT). This first model has a dataset with average data of around 1.0 with small data derivations of 2% for BW and 0.4% for BT. The second model is using the originally collected numbers of (measured BW) and (measured BT). It will have a dataset with data derivation of 3 lbs. between 166 to 169 lbs. for BW along with the data deviation of 0.5 between 97.5 to 98.0 degrees Fahrenheit for BT. He further applies VGT specifically to construct two stress-strain (σ-ε) diagrams with two hysteresis loops corresponding to BW and BT, respectively. These two-loop areas reflect the relative energies associated with input from BW and BT during the time-dependent process of uploading (increasing BW and BT) and unloading (decreasing BW and BT). The following defined stress and strain equations are used to establish the VGT stress-strain diagram in a space domain (SD): VGT strain = ε (FPG) = individual FPG at the present time. VGT stress = σ (based on the change rate of strain, FPG, multiplying with a viscosity factor, BT or BW) = η * (dε/dt) = η * (d-strain/d-time) = (viscosity factor η using individual BT or BW at present time) * (FPG at present time - FPG at a previous time). However, the measurement units for BW (pounds) and BT (degrees Fahrenheit) were defined long ago without deep thought on their biomedical means in terms of their inherent biophysical inter-relationships. To place them on even ground with a sufficient biomedical sense, he has normalized the viscosity factor η of BW and BT respectively, using the following 2 formulas: Normalized BW = BW / average BW (168.3 lbs.); Normalized BT = BT / average BT (97.7-degree F). To control the word size of this article, he omits the repetitive background introduction regarding LEGT and VGT in the research method section. In conclusion, the magnitude of the stress component on the y-axis of the stress-strain diagram, such as the influential forces resulting from two causes (viscosity factors η of BW and BT), is greatly controlled by the values of BW and BT. In the first model using normalized BW and BT, there are no visible differences between the two hysteresis loops due to both normalized values being close to 1.0 with extremely small data deviation of 0.4% to 2%. However, in the second model using the measured data of BW and BT, there are quite visible differences between the two hysteresis loops due to the BW data range of 166 to 169 lbs. with a deviation of 3 lbs. and the BT data range of 97.5 to 98.0 degrees Fahrenheit with a deviation of 0.5 degrees. As a result, in the σ-ε diagram using the original measured data of BW and BT, the BW loop area is obviously larger than the BT loop area. The measured BW values and measured BT values have different numerical scales with a wider data deviation range of 0.5-3.0. On the other hand, the normalized BW and normalized BT have a similar numerical scale of around 1.000 with a narrower data deviation of 0.004-0.02. As a result, these two sets of stress-strain diagrams (σ-ε) appear different, although their curve patterns are similar to each other due to the same values of both FPG (strain) and FPG change rate (strain rate). This article merely focuses on the investigation of the hysteresis loop area size due to viscosity factor η, not on its biomedical explanation or its biophysical illustration.

Keywords: Viscoelastic; Viscoplastic; Viscosity factor; Fasting plasma glucose; Postprandial plasma glucose

Abbreviations: BW: body weight; BT: body temperature; FPG: fasting plasma glucose; PPG: postprandial plasma glucose; LEGT: linear elastic glucose theory; SD: space domain; MPM: math-physical medicine

1. INTRODUCTION

The author was a professional engineer working in the fields of the space shuttle, naval battleships, nuclear power plant, computer hardware and software, artificial intelligence, and semiconductor chips. After retiring from his engineering job, he initiated his self-study and research on internal medicine with an emphasis on biomarker relationship exploration and disease prevention. Since 2010, he has utilized the academic disciplines learned from 7 different universities along with various work experiences to formulate his current medical research work over the past 13 years.

One thing he has learned is that in engineering or medicine, people are frequently seeking answers, illustrations, or explanations for the relationships between the input variable (force on a structure or cause of a disease) and output variable (deformation on a structure or symptom of a disease). However, the relationships between input and output could be expressed with many different matrix formats of 1 x 1, 1 x n, m x 1, or m x n (m or n means different multiple variables). In addition to these mathematical complications, the output resulting from one or more inputs can also become an input of another output i.e., a symptom of certain causes can become a cause of another different symptom. This phenomenon is a complex scenario for a "chain effect". In fact, engineering and biomedical complications are fundamentally mathematical problems that correlate with many inherent physical laws or principles.

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Previously, he applied a signal processing technique to separate 19 components from the combined PPG wave. He identified the carbs/sugar intake amount and post-meal exercise as the two most important contributing factors to PPG formation. In addition, he also discovered more than 5 components causing FPG, including pancreatic beta cells health condition as the baseline, along with BW, sleep, and stress as additional influential forces. For his follow-up study, he identified the self-repairing capability of his pancreatic beta cells which has improved by quality and quantity of his insulin secretion by ~30% over the past 8 years. Based on these findings, he then applied the theory of elasticity from engineering to develop a linear elastic glucose theory (LEGT). This is to predict the PPG value with high prediction accuracy, using carbs/sugar grams and post-meal walking k-steps as two major input components of PPG formation. Based on his BW in the early morning, he predicted his FPG quite accurately.

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In this article, he selected a dataset containing 3 biomarkers, sensor collected FPG, BW, and BT over the past 18 months from 10/1/2020 to 3/27/2022. He then utilized the above-mentioned concepts of the FPG formation and VGT research method to calculate the influences on S.FPG from BW and BT as influential forces.

There are two models in this simple study:

The first model is using normalized numbers of (measured BW / average BW) and (measured BT / average BT). This first model has a dataset with average data of around 1.0 with small data derivations of 2% for BW and 0.4% for BT. The second model is using the originally collected numbers of (measured BW) and (measured BT). It will have a dataset with data derivation of 3 lbs. between 166 to 169 lbs. for BW along with the data deviation of 0.5 between 97.5 to 98.0 degrees Fahrenheit for BT.

He further applies VGT specifically to construct two stress-strain (σ-ε) diagrams with two hysteresis loops corresponding to BW and BT, respectively. These two-loop areas reflect the relative energies associated with input from BW and BT during the time-dependent process of uploading (increasing BW and BT) and unloading (decreasing BW and BT).

The following defined stress and strain equations are used to establish the VGT stress-strain diagram in a space domain (SD):

VGT strain
= ε (FPG)
= individual FPG at the present time

VGT stress
= σ (based on the change rate of strain, FPG, multiplying with a viscosity factor, BT or BW)
= η * (dε/dt)
= η * (d-strain/d-time)
= (viscosity factor η using individual BT or BW at present time) * (FPG at present time - FPG at a previous time)

However, the measurement units for BW (pounds) and BT (degrees Fahrenheit) were defined long ago without deep thought on their biomedical means in terms of their inherent biophysical inter-relationships. To place them on even ground with a sufficient biomedical sense, he has normalized the viscosity factor η of BW and BT respectively, using the following 2 formulas:

Normalized BW
= BW / averaged BW (168.3 lbs.)

Normalized BT
= BT / averaged BT (97.7-degree F)

To control the word size of this article, he omits the repetitive background introduction regarding LEGT and VGT in the research method section.

2. METHODS

The following defined stress and strain equations are used to establish the VGT stress-strain diagram in a space domain (SD):

VGT strain
= ε (FPG)
= individual FPG at the present time

VGT stress
= σ (based on the change rate of strain, FPG, multiplying with a viscosity factor, BT or BW)
= η * (dε/dt)
= η * (d-strain/d-time)
= (viscosity factor η using individual BT or BW at present time) * (FPG at present time - FPG at a previous time)

Note: For a more detailed description, please refer to the "consolidated method" section which is given at the beginning of the special issue.

3. RESULTS

Figure 1 shows background information regarding corrections among BW, BT, and FPG.

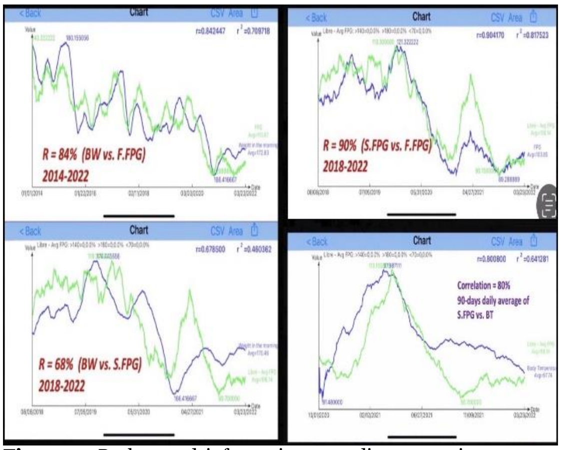

Figure 1: Background information regarding corrections among BW, BT & FPG.

Figure 2 depicts the stress-strain diagram in the space domain of S.FPG vs. normalized BW and normalized BT.

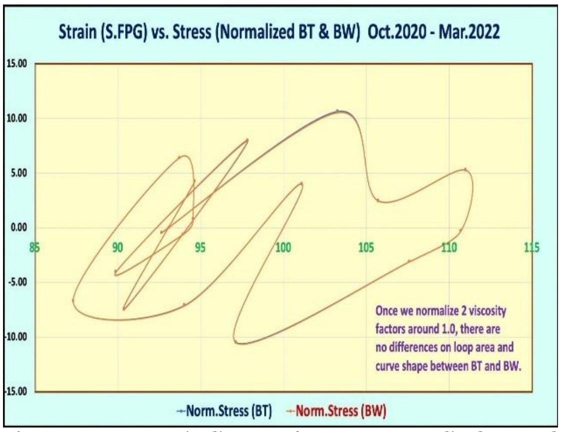

Figure 2: Stress-strain diagram of S.FPG vs. normalized BW and normalized BT.

Figure 3 illustrates the stress-strain diagram in the space domain of S.FPG vs. measured BW and measured BT.

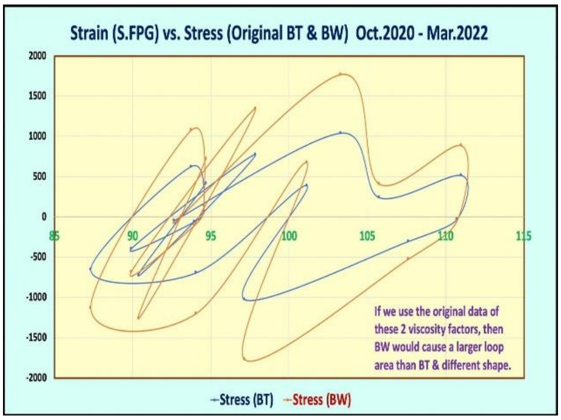

Figure 3: Stress-strain diagram of S.FPG vs. measured BW and measured BT.

Figure 4 is a summarized data table.

3/27/22	Strain	Viscosity 1	Viscosity 2		Viscosity 1 / 97.5	Viscosity 2 / 170	Strain	Normalized	Normalized	Strain	Original Data	Original Data
S.FPG via BT & BW	Meas. S.FPG	Meas. BT	Meas. BW	S.FPG via BT & BW	Norm BT	Norm BW	Meas. S.FPG	Norm.Stress (BT)	Norm.Stress (BW)	Meas. S.FPG	Stress (BT)	Stress (BW)
Y2020-10	93	97.6	167	Y2020-10	0.9986	0.9931	93	0.00	0.00	93	0	0
Y2020-11	93	97.9	166	Y2020-11	1.0016	0.9858	93	-0.45	-0.44	93	-44	-75
Y2020-12	103	97.8	166	Y2020-12	1.0009	0.9890	103	10.65	10.52	103	1041	1771
Y2021-01	106	98.0	167	Y2021-01	1.0025	0.9949	106	2.46	2.44	106	240	410
Y2021-02	111	98.0	168	Y2021-02	1.0030	0.9998	111	5.28	5.26	111	516	885
Y2021-03	111	97.9	168	Y2021-03	1.0019	0.9987	111	-0.30	-0.30	111	-29	-50
Y2021-04	108	97.8	169	Y2021-04	1.0006	1.0046	108	-3.10	-3.11	108	-303	-524
Y2021-05	97	97.6	169	Y2021-05	0.9987	1.0033	97	-10.46	-10.50	97	-1022	-1768
Y2021-06	101	97.7	169	Y2021-06	1.0001	1.0061	101	4.00	4.02	101	391	677
Y2021-07	94	97.7	169	Y2021-07	0.9995	1.0058	94	-7.10	-7.14	94	-694	-1202
Y2021-08	87	97.7	168	Y2021-08	0.9998	0.9979	87	-6.71	-6.70	87	-656	-1127
Y2021-09	94	97.7	168	Y2021-09	0.9996	0.9989	94	6.41	6.40	94	626	1078
Y2021-10	95	97.7	168	Y2021-10	0.9995	1.0007	95	0.82	0.82	95	80	138
Y2021-11	94	97.7	169	Y2021-11	0.9996	1.0043	94	-0.61	-0.61	94	-60	-103
Y2021-12	90	97.6	169	Y2021-12	0.9989	1.0047	90	-4.04	-4.06	90	-394	-683
Y2022-01	98	97.6	169	Y2022-01	0.9987	1.0055	98	7.93	7.98	98	775	1344
Y2022-02	90	97.6	169	Y2022-02	0.9986	1.0048	90	-7.44	-7.49	90	-727	-1260
Y2022-03	95	97.5	169	Y2022-03	0.9978	1.0019	95	4.27	4.29	95	417	722
Average or Sum	98	97.7	168.3	Average or Sum	1.0000	1.0000	98	0.09	0.08	98	9	13
R of S.FPG vs. BT,BW	100%	72%	-6%	R of S.FPG vs. BT,BW	72%	-6%	100%			100%		
R of BWG vs. BT		-45%		R of BWG vs. BT	-45%							

Figure 4: A summarized data table.

4. CONCLUSION

In conclusion, the magnitude of the stress component on the y-axis of the stress-strain diagram, such as the influential forces resulting from two causes (viscosity factors η of BW and BT), is greatly controlled by the values of BW and BT.

In the first model using normalized BW and BT, there are no visible differences between the two hysteresis loops due to both normalized values being close to 1.0 with extremely small data deviation of 0.4% to 2%. However, in the second model using the measured data of BW and BT, there are quite visible differences between the two hysteresis loops due to the BW data range of 166 to 169 lbs. with a deviation of 3 lbs. and the BT data range of 97.5 to 98.0 degrees Fahrenheit with a deviation of 0.5 degrees. As a result, in the σ-ε diagram using the original measured data of BW and BT, the BW loop area is obviously larger than the BT loop area.

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This article merely focuses on the investigation of the hysteresis loop area size due to viscosity factor η, not on its biomedical explanation or its biophysical illustration.

5. REFERENCES

For editing purposes, the majority of the references in this paper, which are self-references, have been removed. Only references from other authors' published sources remain. The bibliography of the author's original self-references can be viewed at www.eclairemd.com.

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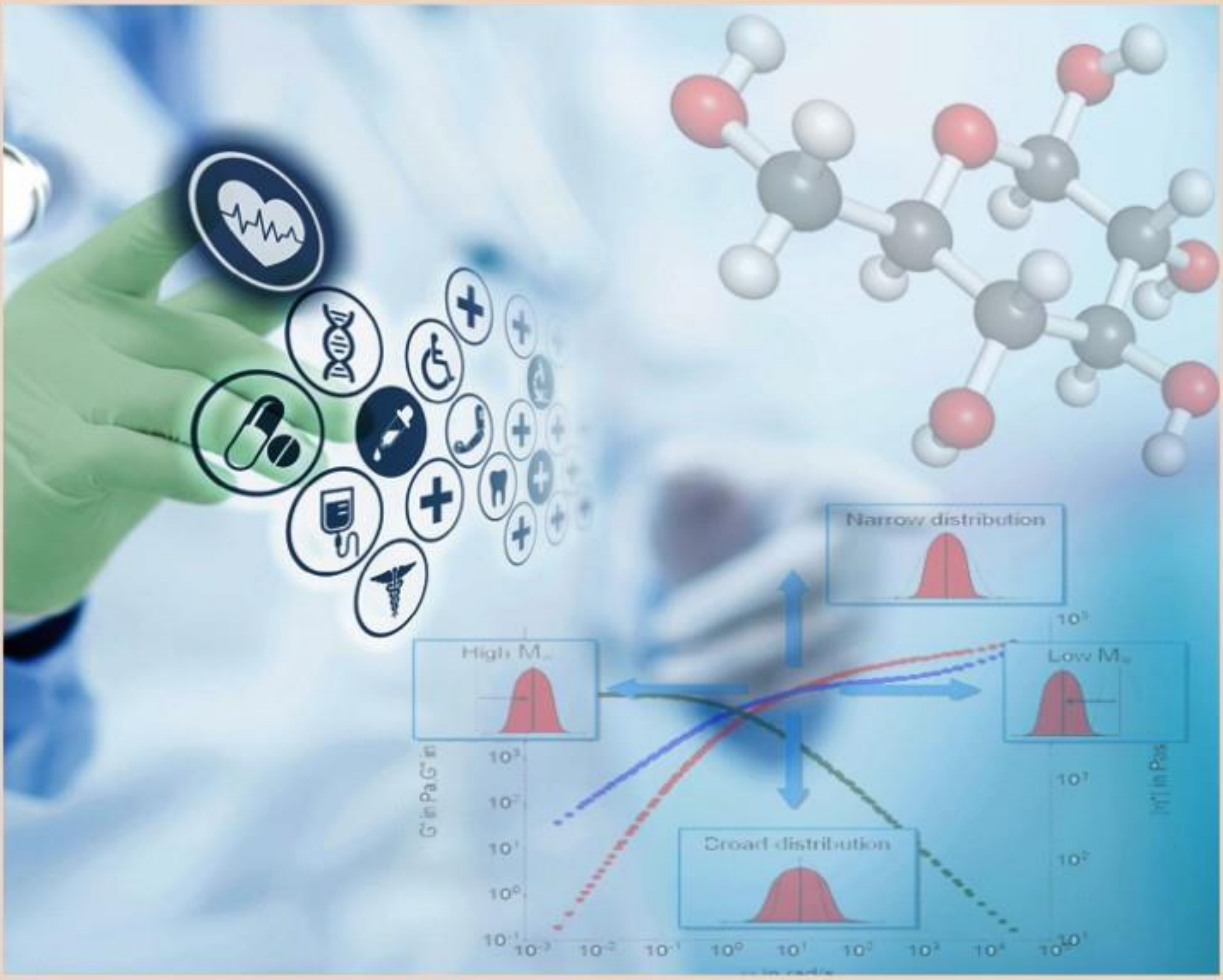

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2022