SWEN 90004 Report

Assignment 2

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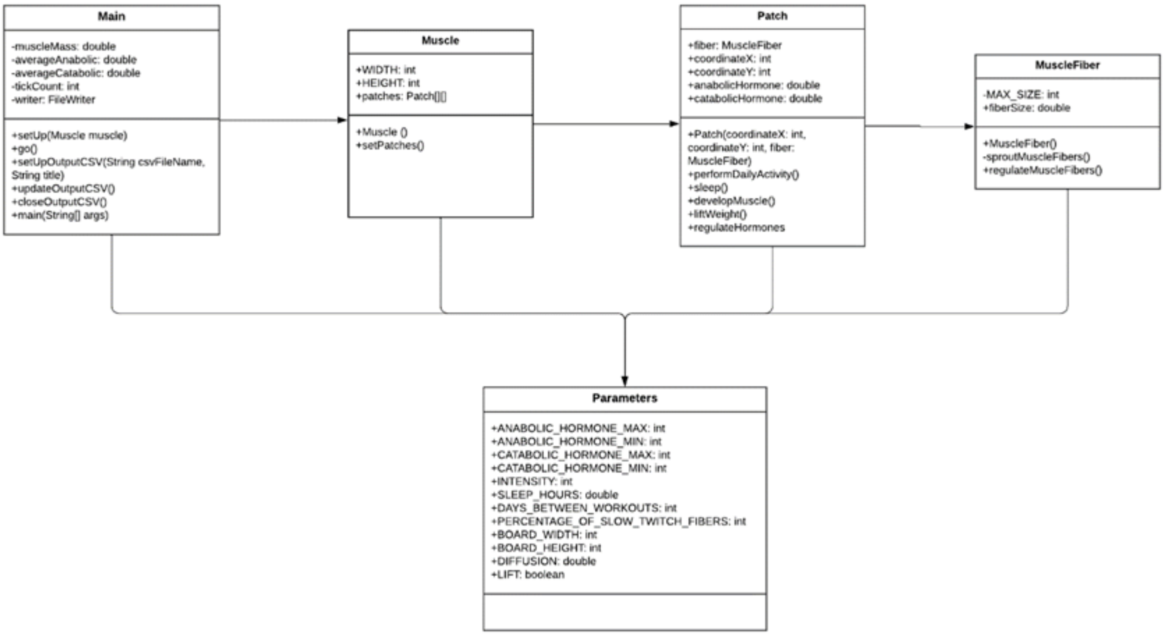
Background for the Model

The muscle development model is a physiological model of muscle growth that helps to understand the relationship between muscle growth and five factors: **frequency**, **sleep**, **intensity**, **genetic** and diet(In this model we assume the perfect diet). Different values of these factors lead to changes in the amount of anabolic hormone and catabolic hormone around muscle fibers, and these two hormones act together to cause muscle growth or breakdown.
Users can use this model to understand the relationship between muscle growth and four factors, and to understand what conditions are more suitable for muscle growth. This information may be helpful for some newbies who want to work out. To achieve the best result for muscular development, it is essential to understand all of the five factors and put them into balance. The balance of the combination will be different during different periods for an individual.

Design of our Model

To ensure a more precise alignment with the class functionality, revisions have been made to the class names compared to the initial proposal. However, the overall number of classes remains unchanged, consisting of a total of five classes, as depicted in the UML class diagram below:



Instructions to build and run this muscle development model are provided in the comments of the "Main" class. In this implementation, a muscle comprises multiple muscle fibers, and the model incorporates patches that simulate individual muscle fibers. These muscle fibers are influenced by changes in two hormones mentioned in the background. Consequently, multiple patches are utilized to simulate the development of each muscle fiber, collectively forming a comprehensive muscle development system.

In other words, the "Main" class assumes the primary responsibility of executing the muscle development model. By executing the main() function in Main, the project starts running and finally outputs the data into a data.csv file.

The "Muscle" class offers rooms for the growth of muscle fibers. In this implementation, it can be represented as an N*M board/table, where N >= 2 and M >= 2.

The "Patch" class controls the relationship between muscle fibers and five hormones. In this class, several functions represent the daily activities of the muscle owner, which influence the hormones. The hormones, in turn, influence the growth of muscle fibers. Additionally, hormones will diffuse to their neighboring patches.

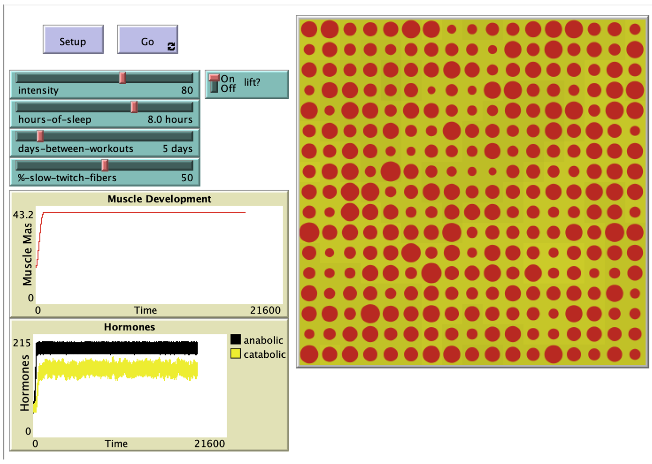
The "MuscleFiber" class represents muscle fiber. Each fiber may have a different maximum size according to its generic. The size of the muscle fiber can also be increased over time.

The "Params" class controls the parameters for the model, such as intensity, sleep hours, days between workouts, and whether to start training (lifting) or not.

<u>Results of Experiments</u>

- **Standard sample**

In this model, we set up the standard sample parameters as below:
Intensity = 80
Hour of sleep = 8.0 hours
Days between workouts = 5 days
Percentage of slow twitch fibers = 50
Lift = On



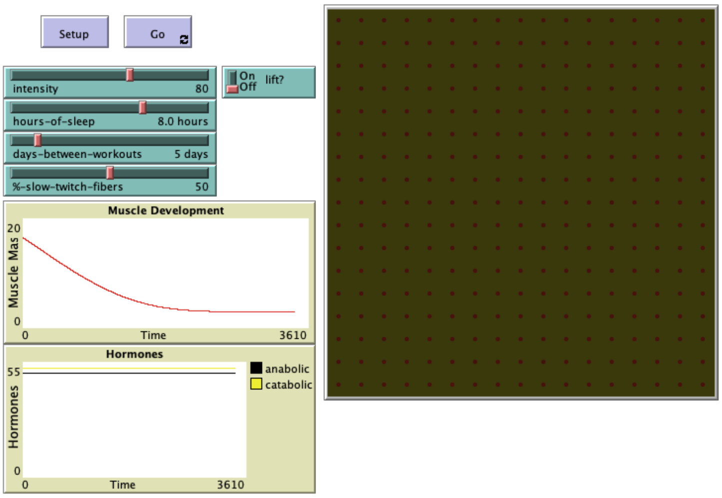
We are simulating the data on NetLogo which an average person could have. He is a person with a healthy sleeping time and an average talent. Also, he workouts once a week with a standard intensity. After a period of workouts, the muscle mass reached the equilibrium value which is around 40, and the anabolic values and catabolic values are about 180 and 110 respectively.

	Days/Ticks	averageAnabolic	averageCatabolic	muscleMass
1	1	67.06810284842419	64.5282333362418	1580.8508301865215
2	2	62.458939663624385	59.87060360853093	1581.732794705182
3	3	58.28689373509583	55.847283436190445	1582.6715180999372
4	4	54.63431095882679	52.95243582374557	1583.371087035201
5	5	51.77078032850514	52.0728214791807	1583.1909165849052

	Days/Ticks	averageAnabolic	averageCatabolic	muscleMass
932	932	182.3623399946956	110.08717311477895	3982.54020528829
933	933	176.90615819691754	104.55922758258797	3982.5607034635286
934	934	171.48927114166665	99.10595504384203	3982.580858799224
935	935	166.11378451448996	93.73131927495668	3982.6006772681762
936	936	186.47902521203872	115.4207690952176	3982.621887973772
937	937	181.95169889177316	109.82323469553648	3982.642673835766
938	938	176.49335418395694	104.29691414451868	3982.663070251671З

In our replication model, the anabolic value increased from around 60 to 180 which reached the equilibrium, and the catabolic value increased from around 60 to 110 which reached the equilibrium. The muscle mass increased from around 1500 to 4000. The data are as expected.

- **Without Lifting**



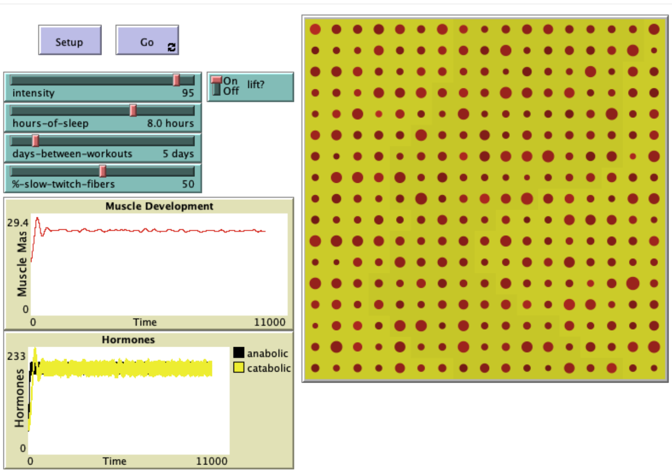
In this experiment, we changed the lift to off, which means the person in this situation is without any workouts. In the NetLogo model, the muscle mass keeps decreasing from around 16 to about 3. The anabolic and catabolic values keep being the lowest values (50 and 52).

	Days/Ticks	averageAnabolic	averageCatabolic	muscleMass
1	1	50.0	52.0	1585.548563626393
2	2	50.0	52.0	1584.5640366149235
3	3	50.0	52.0	1583.5795096034544
4	4	50.0	52.0	1582.5949825919856
5	5	50.0	52.0	1581.610455580515
6	6	50.0	52.0	1580.625928569046

	Days/Ticks	averageAnabolic	averageCatabolic	muscleMass
7598	7598	50.0	52.0	289.0
7599	7599	50.0	52.0	289.0
7600	7600	50.0	52.0	289.0
7601	7601	50.0	52.0	289.0
7602	7602	50.0	52.0	289.0

According to the data from our replication model, the muscle mass decreased from 1580 to 289, and the anabolic and catabolic values are keeping stable at 50 and 52, as expected.

- **Higher Intensity**



In this experiment, I kept other parameters not changing and increased the intensity to 95. This means the person in this situation increases the intensity of his workouts. The muscle mass increased from around 16 to the maximum value of about 30, and the mass reached the equilibrium value which is around 27. The anabolic and catabolic values reached the equilibrium of around 180.

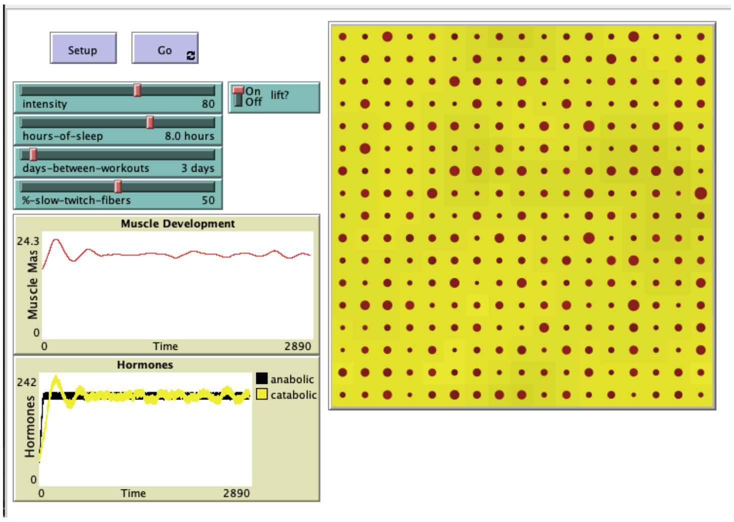
	Days/Ticks	averageAnabolic	averageCatabolic	muscleMass
1	1	74.67889789457499	70.20123328695847	1617.05282190427
2	2	69.60563934767589	64.74545471844944	1618.779529201042
3	3	64.69569945696264	59.591729714223156	1620.7656615237663
4	4	59.97786337777087	54.98971241775598	1622.8735292779113
5	5	55.59035371983475	52.47498346934913	1624.254698565277

	Days/Ticks	averageAnabolic	averageCatabolic	muscleMass
299	299	182.37658786858196	176.59555967558404	3099.137566378805
300	300	176.6782169178869	170.15869459150582	3100.0744814801906
301	301	197.84885701183802	199.1123612253718	3099.944867383333
302	302	194.20638358725748	192.50130727825675	3100.1803346013985
303	303	188.42703833640678	185.93840826832158	3100.5223371542943

	Days/Ticks	averageAnabolic	averageCatabolic	muscleMass
5510	5510	175.61803191932432	176.46139005102341	2751.8584537427273
5511	5511	197.45608252043772	202.95463787957178	2751.184564324869
5512	5512	193.32222141258458	196.23293311243606	2750.818393755696
5513	5513	187.416672143161	189.55560447497314	2750.537571159933

In our replication model, the anabolic and catabolic values increased from around 70 to 180, and the muscle mass increased from around 1600 to the peak of 3100, and fell back to the equilibrium value of 2750; the data was as expected.

- **Workout More Frequently**



In this experiment, we kept other parameters not changing and increased the frequency of workouts to every 3 days once. The muscle mass increased from around 16 to the maximum value of about 25, and it reached the equilibrium value which is around 21. The anabolic hormones and catabolic hormones values are around 200 at the equilibrium.

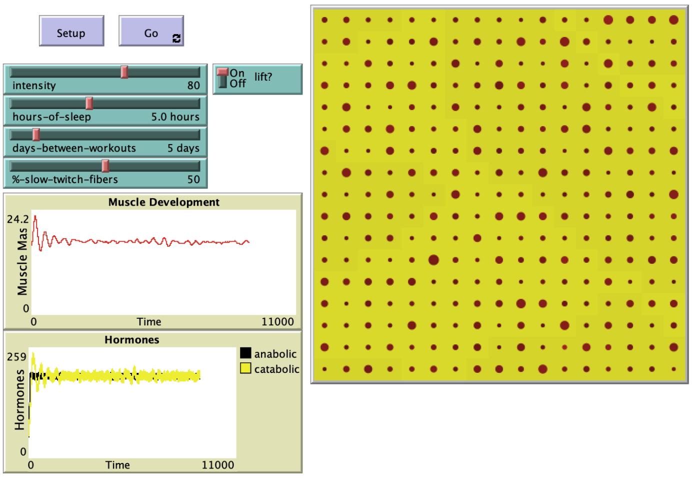
	Days/Ticks	averageAnabolic	averageCatabolic	muscleMass
1	1	65.86144601857502	63.62830547114834	1578.9490520702836
2	2	61.357745379393165	59.12291734010644	1579.6953439437227
3	3	57.339966400379396	55.297822056847245	1580.4733697848162
4	4	75.66579903159145	68.83388514283968	1582.5715617930432
5	5	70.58910513840043	63.67111566440823	1584.9411891242285

	Days/Ticks	averageAnabolic	averageCatabolic	muscleMass
210	210	182.00723742236158	197.15557447919815	2455.17566995663
211	211	192.87731598249025	212.56779647997135	2452.830276245509
212	212	188.32214491892145	205.71044250781253	2450.69605531748
213	213	182.35582656444154	198.87186037347618	2448.59524095225
214	214	191.8840722438468	213.46977953167362	2446.00740906995

	Days/Ticks	averageAnabolic	averageCatabolic	muscleMass
2567	2567	184.8427184396549	187.94747186672623	2117.1845731291387
2568	2568	178.75621832383067	181.13637203918663	2116.893708950715
2569	2569	192.39218985124114	196.5421208998026	2116.407410443382

In our replication model, the anabolic and catabolic values increased from around 60 to 200, and the muscle mass increased from around 1600 to the peak of 2450, and fell back to the equilibrium value of 2100; the data was as expected.

- **Less Sleeping**



In this experiment, I kept other parameters not changing and decreased the sleeping hour to 5 hours per day. The maximum muscle mass reached 23, but the muscle mass decreased to the equilibrium value which is around 18. The anabolic hormones and catabolic hormones values are around 180 at the equilibrium.

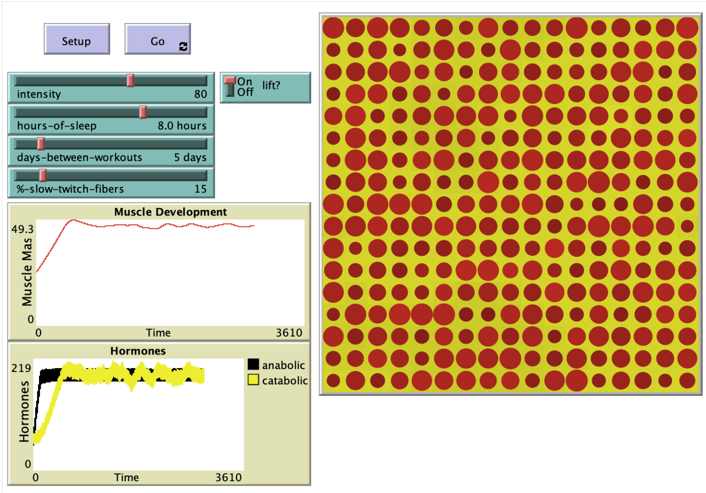
	Days/Ticks	averageAnabolic	averageCatabolic	muscleMass
1	1	69.08426733106363	66.45254236959973	1653.1782966229905
2	2	66.58653430919877	63.539401053529375	1654.197512194498
3	3	64.14999225530113	60.785367697267255	1655.43749437199
4	4	61.76103205222174	58.197488829209306	1656.8373819913431

	Days/Ticks	averageAnabolic	averageCatabolic	muscleMass
146	146	193.63398261157778	179.5633013582857	2407.2320746881473
147	147	192.21636192862184	176.00037984639178	2409.5310244341695
148	148	189.20724463134096	172.45479151134109	2411.9317082041075
149	149	186.2068751749584	168.92741655077418	2414.441055367102

	Days/Ticks	averageAnabolic	averageCatabolic	muscleMass
5837	5837	190.90506739655527	190.06189597979625	1830.4216947314942
5838	5838	187.60985012336013	186.22920886551873	1830.64226379799
5839	5839	184.32747393859447	182.4122925186336	1830.9359324828604
5840	5840	181.05887099039248	178.61230249222052	1831.3065860253878

In our replication model, the anabolic and catabolic values increased from around 60 to 180, and the muscle mass oscillated at around 17, and the peak was at 24; the data was as expected.

- **The lower percentage of Slow Twitch Fibers**



In this experiment, I kept other parameters not changing and decreased the percentage of slow twitch fibers to 15%, which means the person's muscle is more gifted. The muscle mass increased from 24 to the equilibrium value which is around 50. The anabolic hormones and catabolic hormones values increased from around 70 to 180 at the equilibrium.

	Days/Ticks	averageAnabolic	averageCatabolic	muscleMass
1	1	74.20259044280095	70.16470466363086	2407.3257941448414
2	2	69.51395396418927	65.14189823803994	2408.7421495364
3	3	65.03579790167792	60.610043814175185	2410.3342132589423
4	4	60.80221829464134	56.50792778381959	2412.0254772894004

	Days/Ticks	averageAnabolic	averageCatabolic	muscleMass
6139	6139	176.21448900726398	175.8011987860195	5146.254683231122
6140	6140	171.037783725547	169.76739073716814	5146.250345763028
6141	6141	189.05999892880584	193.67053053402108	5145.614345255326
6142	6142	185.63143308375854	187.5034878499225	5145.268255304306
6143	6143	180.38549184934234	181.37696087824224	5145.009557616596
6144	6144	175.17505942777703	175.29440734131492	5144.8497301701

In our replication model, the muscle mass increased from around 2400 to 5100, and the anabolic hormones and catabolic hormones values increased from about 70 to 180 at the equilibrium; data was as expected.

Discussion

After observing the experimental results, we draw the following conclusions:

- Under standard conditions, our model yields results similar to Netlogo's. Muscle mass will first increase and then remain stable at a certain value, indicating that the rate of muscle gain and decomposition is equal to this value under these parameters.
- When the lift parameter is changed to off, the total amount of muscle decreases at a certain rate until it is reduced to the set minimum. The mean value of anabolic around fiber remains at the minimum value of 50, and the minimum value of catabolic around fiber is also at the minimum value of 52. This means you must keep lifting weights to gain or maintain muscle mass.
- When the intensity parameter was increased to 95, muscle mass stopped at about 30 and then remained at about 27. This is significantly lower than standard muscle mass. This experience shows that an intense workout can affect muscle composition and that the best intensity for the workout needs to be found for each individual.
- If the frequency is increased to once every three days, then the muscle mass gain is also less than normal. This means that if you exercise too often, muscles don't get enough rest, which affects muscle synthesis.

- When the parameter of sleeping is reduced from 8 hours to 5 hours, it can be observed that the mean value of anabolic has no obvious change compared with the standard condition, but the mean value of catabolic increases from about 100 to 180, which results in the muscle mass only maintaining at about 23, which is lower than the standard condition. This shows how important adequate sleep is for muscle growth.
- The final experiment was to change the slow-twitch-fibers value, which means changing your genetic fibers. It can be seen from the figure that when the value of the slow-twitch-fibers parameter drops to 15, the muscle gain remains at about 50 fibers, indicating that genetic factors have an obvious effect on muscle mass gain.

Overall, our model is highly similar to the Netlogo model. Moreover, the values of hormones and muscle mass of our company are consistent with those calculated by Netlogo, but the units of our muscle mass are different from those of Netlogo.

Reference List (Bibliography)

[1] Wilensky, U. (n.d.). Diffuse Primitive. NetLogo Models Library. Retrieved May 26, 2023, from https://ccl.northwestern.edu/netlogo/bind/primitive/diffuse.html

[2] MuscleDevelopment. NetLogo Models Library. Retrieved May 26, 2023, from http://ccl.northwestern.edu/netlogo/models/MuscleDevelopment

Appendix

Success:

Each team member's unwavering commitment to collaboration and diligent completion of their assigned tasks. When someone faces a challenge, other team members actively provide guidance, offer suggestions, and assist in improving the assignment. Ultimately, the team completed all tasks within the designated timeframe while upholding high-quality standards.

Challenge:

The main challenge we encountered is my limited understanding of the muscle development model, which occasionally led to minor errors. For instance, initially, we overlooked the fact that during the diffusion process, if there are fewer than eight adjacent patches, any excess hormones should return to the original patch. Additionally, we mistakenly assumed that the diffusion rate followed a distribution pattern rather than retaining its initial value.

Modifications of plan:

Due to encountered errors, more time was needed for code development than initially anticipated. Specific functionalities of certain classes were updated, and a revised approach was taken to prioritize simpler classes for earlier completion, allowing team members to assist with more complex classes. Additionally, it was agreed that team members who contributed less in coding would focus on making contributions during the documentation phase.