CT - I FCB

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1.(a) Assume the data set X is provided. Size of the data set is 10×3 (matrix) write MATLAB code plotting the data set as scatter plot involving following conditions.

i) plot only 1st and 3rd column neglecting 2nd column.

ii) change the marker types while plotting for each selected column

iii) write axis titles, legends and line width as 1.5.

iv) plot 2nd column as bar plot including axis details.

=> >> X = rand(10,3); y = [1;2;3;4;5;6;7;8;9;10];
>> plot(y, X(:,1), '+g', y, X(:,3), '*b', 'LineWidth', 1.5);
>> title('Data Set x'); xlabel('row numbers');
>> ylabel('Column 1 & 3'); legend('column 1', 'column 3');
>> bar(y, X(:,2)); title('Data Set x');
>> xlabel('row number ->'); ylabel('column 2 values');

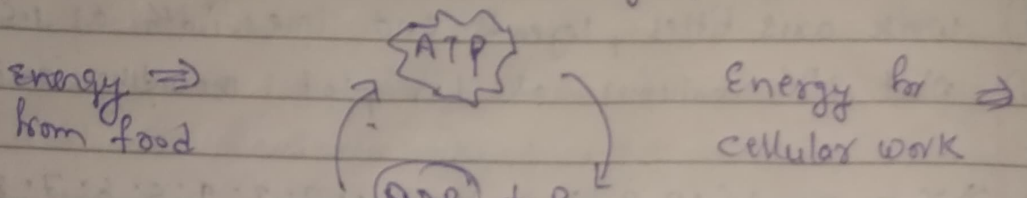
1.(b) Write detailed notes on cellular respiration. Include short notes on glycolysis and TCA cycle.

=> Energy is produced in living organism by conversion of ATP molecules into ADP molecules & cells keep on converting ADP molecules back into ATP molecule these processes known as respiration.

Breathing is a physical process involving exchange of gases from surrounding to cells & respiration is a chemical process of converting energy from ATP molecule obtained from food (organic compounds).

Oxygen diffuse from alveoli to capillaries & form loosely bonds forming oxyhemoglobin which travels through blood & seperate oxygen in body tissue, where CO_2 & water diffuse into blood from cells via capillaries which diffuse back into alveoli from capillaries & exhaled out. CO_2 is

carried in form of bicarbonate ions (HCO_3^-).
Cellular respiration is a series of enzyme controlled reaction in which energy released by breaking of glucose bonds transferred to bonds formation of ATP molecule.
Aerobic respiration occur in mitochondria &
Anaerobic respiration occur in cytoplasm.



ATP - ADP cycle

Cellular respiration occur in 3 pathways Glycolysis, Krebs cycle & Electron Transport chain.

Glycolysis releases 2 ATP energy only then it lead. to either Krebs cycle & electron transport chain (if oxygen present) or (Alcoholic fermentation or Lactic Acid Fermentation) (if oxygen is absent)
In mitochondria Krebs cycle & electron transport chain produce lots of ATP
equation:-

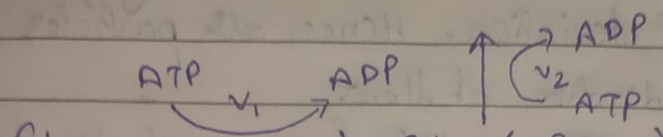
$6O_2 + C_6H_{12}O_6 \longrightarrow 6CO_2 + 6H_2O +$ energy (ATP)

oxygen — glucose — carbon dioxide — water

Tricarboxylic acid cycle also called Krebs cycle and citric acid cycle, the second stage of cellular respiration, the three stage process by which living cells break down organic fuel molecules in the presence of oxygen to harvest the energy they need to grow and divide.
In all organism except bacteria TCA cycle is carried

out in matrix of intracellular structures called mitochondria.

(c) Write ODE model for glycolytic pathway including only following metabolites.



$$\frac{d}{dt}\text{Gluc 6-P} = v_1 - v_2 - v_3$$

$$\frac{d}{dt}\text{Fruc 6-P} = v_3$$

$$\frac{d}{dt}\text{ATP} = -v_1 - v_2$$

$$\frac{d}{dt}\text{ADP} = v_1 + v_2$$

$$\frac{d}{dt}\text{Glucose} = -v_1$$

(d) In detail discuss blood flow mechanism in human body. Also include flow properties including streamline and turbulent flow. Mention the mathematical expression with description for Reynolds number.

⇒ Blood comes into right artium from the body, moves into the right ventricle and is pushed into pulmonary arteries in the lungs. After picking up oxygen, the blood travels back to the heart through the pulmonary veins into the left artium, to the left ventricle and out to the body's tissues through the aorta.

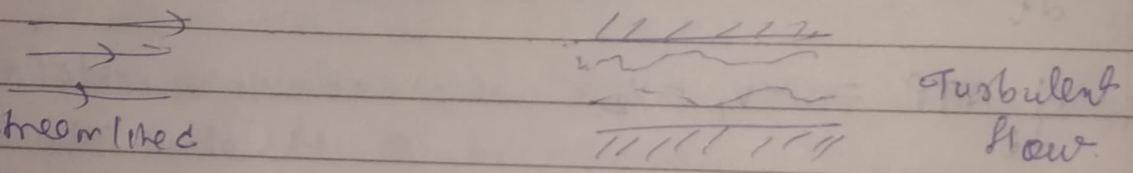
There are two types of flow :-

Steady flow - The flow in which velocity of fluid is constant at any point is called as steady flow.

Unsteady flow - when flow is unsteady, fluid velocity differs between any two points.

Laminar / Streamlined flow; All the particles proceed along smooth parallel paths and all particles on any path will follow it without deviation. Hence all particles have a velocity only in direction of flow.

Turbulent flow: The particles have a velocity such that they move in an irregular manner through the flow field. Each particle has superimposed on its mean velocity fluctuating velocity components both transverse to and in the direction of the net flow.



The streamlines in a laminar flow follow the equation of continuity, i.e., Av = constant (A is cross sectional area of the fluid flow, and v is the velocity of fluid at that point.

Av = Volume flux or flow rate of fluid, which remains constant for steady flow.

Reynolds number is a dimensionless quantity that is used to determine the type of flow pattern as laminar or turbulent while flowing through a pipe. Reynolds number is defined as the ratio of inertial forces to that of viscous forces.

$$Re = \frac{\rho V D}{\mu}$$

ρ → density of fluid, V → velocity of flow, D → Pipe di, μ → viscosity of fluid

C
Reynolds number

$Re > 2000$ ⇒ turbulent flow

$Re < 2000$ ⇒ laminar / streamlined

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Q. (a) State difference between breathing and respiration.

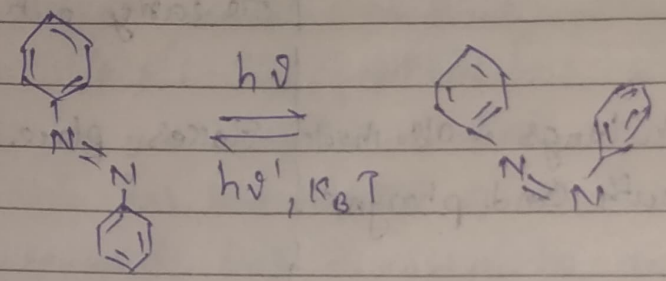
⇒

Breathing	Cellular Respiration
Involves process of inhaling oxygen & exhaling carbon dioxide	Cellular respiration is process of breaking down of glucose to produce energy, which is then used by cells to carry out cellular function.
Takes place in lungs & also involves nose, mouth and pharynx.	Takes place in cells.
It is voluntary as well as an involuntary physical process. (breathing during sleep is involuntary, breathing is voluntary when we speak, swim or for relaxation techniques)	Respiration is an involuntary chemical process.
No production of energy in this process	Energy produced & released in form of ATP.
As it occurs outside cells, it is called extracellular process	As it occurs inside cells, it is called intracellular process.
No enzyme used in this process	A large number of enzyme used.

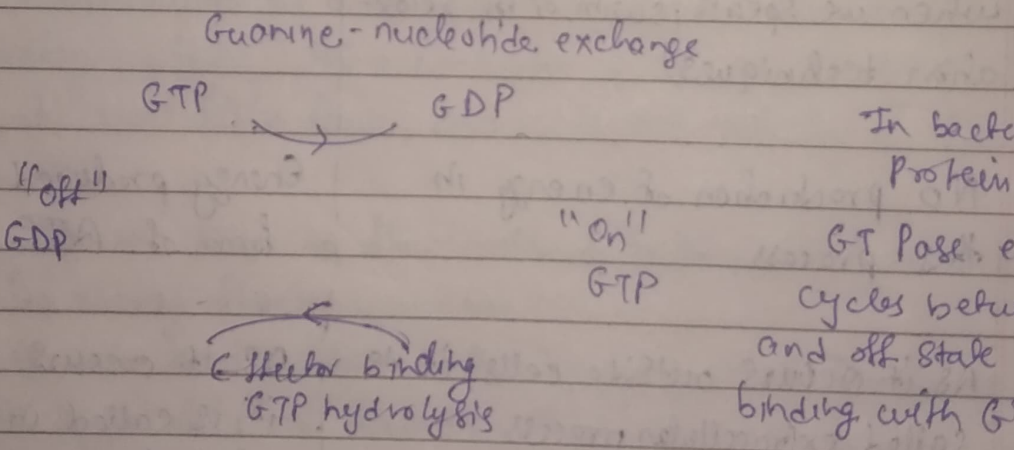
Q. (b) What do you understand by molecular switch? Explain with examples.

⇒ A molecular switch is a molecule that can be reversibly shifted between two or more stable states with help of stimulus factors stimulating switching process: Ph, Light, Temperature,

presence of ions, electricity, other heavy metal ions.
Acido chromic molecular switches: Ph indicators and plants like rose, cornflowers.
Photochromic molecular switches: works with specific wavelength of light. Examples Biotin or vitamin B.



cis-trans isomerisation of azo benzene exposed to heating at light.
Nanoparticle switches: Au, Ag, Cu, Ni, Cr all nanoparticle posses this particular switch.



Q.(c) Describe flux balance analysis with examples with application in detail.

⇒ The stoichiometric analysis can be done in various ways to simplify system and to limit solution space. One of such technique used to completely analyse metabolic genotype of microbial strains is FBA (flux balance analysis).
- relies on balancing metabolic fluxes
- is based on fundamental law of mass conservation.

- is performed under steady-state conditions (eg. of constraint)
- requires information only about:
  (i) Stoichiometric of metabolic pathways.
  (ii) metabolic demands
  (iii) and a few strain specific parameters.
- it does not require enzymatic kinetic data.

A flux balance can be written for each metabolite (x_i) within a metabolic system to yield dynamic mass balance equations that interconnect various metabolites.
(Fundamental principle in FBA is conservation of mass)

Dynamic mass balance for x_i :-

$$\frac{dx_i}{dt} = v_{synthesis} - v_{degradation} - (v_{use} - v_{trans})$$

- Rate of accumulation of x_i = Net rate of production
- v_{use}: Growth and maintenance requirement of cell (determined accurately by cellular composition)
- v_{trans}: uptake or secretion (can be determined experimentally)

$$\therefore \frac{dx_i}{dt} = v_{syn} - v_{deg} - b_i$$

b_i → net transport out of our defined metabolic system.

For a metabolic network :- m metabolites
n metabolic fluxes
∴ all transient material balances represented by single equation matrix

$$\frac{dx}{dt} = S \cdot v - b$$

- $\frac{dx}{dt}$ → m dimensional vector of metabolites amounts per cell
- S → stoichiometric mxn matrix
- v → vector of n metabolic fluxes
- b → vector of known metabolic demands

S_{ij} = amount of i^{th} compound produced per unit of flux of j^{th} reaction.

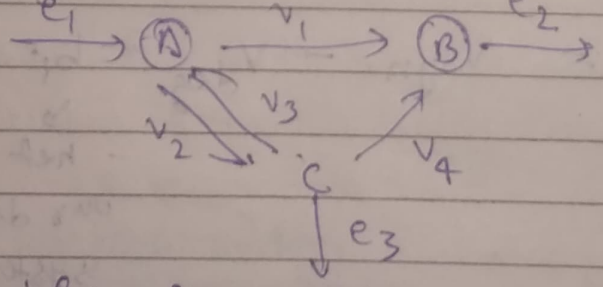
for steady-state behaviour because time constant of metabolites are very rapid compared to cell growth

$$\Rightarrow \frac{dx}{dt} = 0 \Rightarrow \{S \cdot v = b\}$$

(Over long periods of time, formation fluxes of metabolite must be balanced by degradation fluxes. Otherwise, significant amounts of metabolite will accumulate inside metabolic network).

It's applications are to improve bacterial growth.
for eg:- Recombinant E.coli bacteria grown in tanks and used for industrial production of:-
insulin (for diabetics), human growth hormone, ~~erythroprotein~~ & erythropoietin (EPO) for treating anaemia and many more.

2.(d) for this write linear differential equations :-



write stoichiometric matrix.
Hint: Include rate of change of A, B and C with velocities of v_1 to v_4 and e_1 to e_3

⇒ Linear differential equations

$$\frac{dA}{dt} = -v_1 - v_2 + v_3 + e_1$$

$$\frac{dB}{dt} = v_1 + v_4 - e_2$$

$$\frac{dC}{dt} = v_2 - v_3 - v_4 - e_3$$

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Stoichiometric matrix:-

	V_1	V_2	V_3	V_4	e_1	e_2	e_3
A	-1	-1	1	0	1	0	0
B	1	0	0	1	0	-1	0
C	0	1	-1	-1	0	0	-1

Linear transformation:-

$$\frac{dx}{dt} = S * v$$

$$\begin{bmatrix} dA/dt \\ dB/dt \\ dC/dt \end{bmatrix}_{3\times 1} = \begin{bmatrix} -1 & -1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 & -1 & 0 \\ 0 & 1 & -1 & -1 & 0 & 0 & -1 \end{bmatrix}_{3\times 7} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ e_1 \\ e_2 \\ e_3 \end{bmatrix}_{7\times 1}$$

Dynamic mass balance (Steady State)

$$0 = S * v$$

$$\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} -1 & -1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 & -1 & 0 \\ 0 & 1 & -1 & -1 & 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ e_1 \\ e_2 \\ e_3 \end{bmatrix}$$

2. (a) Write a brief note on graph theory.

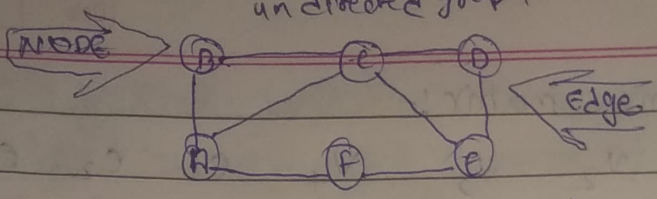
⇒ A graph is a data structure defined by two components:

(i) A node or a vertex (ii) An edge E or ordered pair is a connection between two nodes.

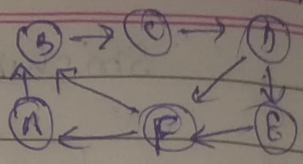
The connection is identified by unique pair (u, v). This is ordered because (u, v) not same as (v, u).

(P.T.O)

undirected graph



Directed graph



Graph is a data structure which is used extensively in our real-life.

Social network: Each user represented as node all their activities represented as an edge between nodes.

Google Maps: Various locations represented as vertices / nodes and roads as edges.

Graph theory is used to find shortest path between two nodes

Adjacent node: A node 'v' said to be adjacent node of 'u' if and only if there exists an edge between 'u' and 'v'.

Degree of node: In undirected graph number of nodes incident on a node is degree.

In case of directed graph, Indegree of node is number of arriving edges to a node.

Outdegree of node is number of departing edge to node.

Path: A path of length 'n' from node 'u' to node 'v' is defined as sequence of n+1 nodes.

$$P(u,v) = (v_0, v_1, v_2, \ldots v_n)$$

A path simple if all nodes are distinct, exception is source and destination are same.

Isolated node: A node with degree 0 known as isolated node.

Graph

- Directed graph
  - DAG
  - Tree
- Undirected graph
  - connected
  - complete
  - Biconnected

Directed Acyclic graph: Directed graph with no cycle. (no edge starting & ending at same node).

Tree: Restricted form of graph: DAG with a restriction that child can have only one parent.

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Connected graph: when path between every pair of nodes. (no unreachable / isolated node)

Complete graph: Each pair of vertices connected by edge.
$\frac{n(n-1)}{2}$ edges (for n nodes). every node is adjacent to all other edges.

Biconnected graph: connected graph cannot broken into further pieces by deletion of any vertex. graph with no articulation point