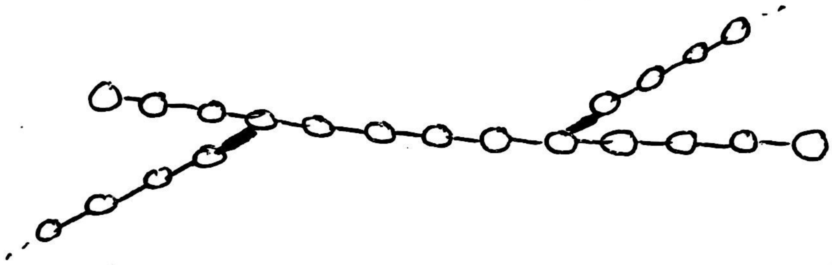
Glycogen" Degradation + Synthesis

↳ Homopolysaccharide of α-D glucose in Liver and muscles



* Highly Branched
* Bonds α (1-4)
  α (1-6) at branch points
* average chain length in glycogen **13 Glucose** (optimum length)

Glycogen Degradation

→ Glucose in Blood / Muscles

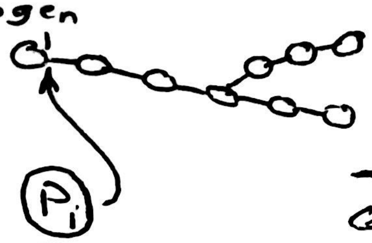
كسر → <u>Glycogen to provide Glucose</u>

* Because glycogen is highly Branched it allows the release of glucose "many at once" أكثر من واحد في نفس الوقت

* Liver glycogen Serves all the body
* Muscle glycogen Serves only the muscles.

α (1-4) bond → by Glycogen phosphorylase

Glycogen



(Pi) not from ATP

→ Glucose-1-P (Glycogen phosphorylase)

تكسير الـ Glycogen لا يحتاج ATP

Glucose-1-P → (phosphoglucomutase) → glucose-6-P

glucose-6-P → (muscles) → Glycolysis

glucose-6-P → (liver, glucose-6 phosphatase) → Glucose

Glucose: Go to blood to serve all the body

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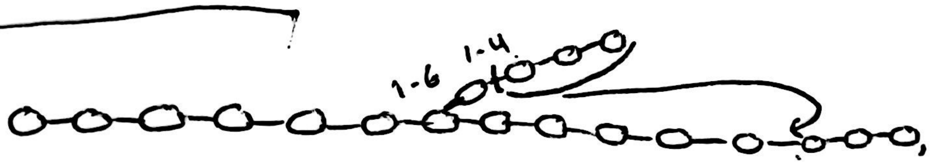
* α (1-6) → by Debranching Enzymes

How they work?

* Glycogen phospherylase leave a limit branch of "4 glucose" (سلسلة قصيرة طولها 4 Glucose)

* Debranching enzymes remove a limit branch of 3 glucose by breaking (1) (α 1-4) and put it (2) to the linear chain by α(1-4), then break (3) (remove) the remaining glucose by breaking α (1-6) bond.



Q: which give me more energy in muscle. Free glucose or from glycogen?

Glucose

↓ (نستهلك ATP)

Glucose-6-P

↓
↓
↓

2 ATP
الحصيلة

Glycogen

↓ (وفرنا ATP) (تجاوزنا الخطوة الأولى)

Glucose-6-P

↓
↓
↓

3 ATP
الحصيلة

So, when we use glycogen the net ATP results will be 3ATP, because we Save 1 ATP by bypassing (تجاوزنا) the first step

So, Glycogen is more effective as energy source

Note:- when Glucose ↓, we use glycogen then fat as sources of energy

* in short distance races (400 m - 1 Km) Glycogen storage is important

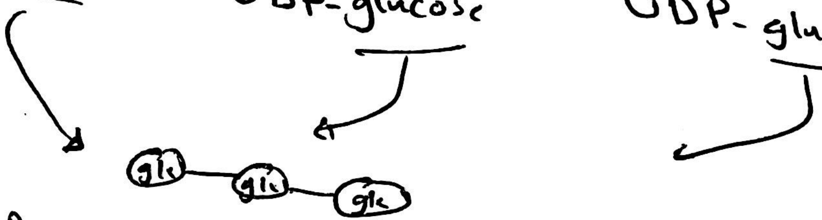
* in long distance races, fat storage is important (marathon)

Glycogen Synthesis

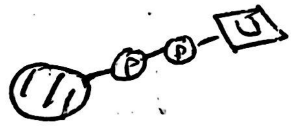
need energy

UTP not ATP

UDP-glucose   UDP-glucose   UDP-glucose



* Synthesis of UDP-glucose



Glucose_1_P + UTP ⟶ UDP-glucose

\+

Pyrophosphate

PPi (Phospate linked with Phospate)

$\Delta G \approx$ Zero

"UDP-glucose" Pyrophosphorylase

$$PP_i \longrightarrow 2P_i \qquad \Delta G = -7.3 \text{ Kcal/mole}$$

Pyrophosphatase

How to make UDP?

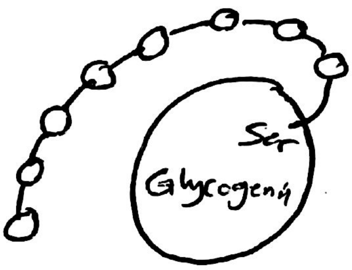
* UDP + ATP ⟶ UTP + ADP

Now we take glucose from UDP-glucose and link the together by "Glycogen Synthase"

- Only α 1-4 ⟵ لو مشروط
- need primer "growing chain"

* The primer is Synthesized by Glycogenine

will make a primer of 8-glucose
طولها



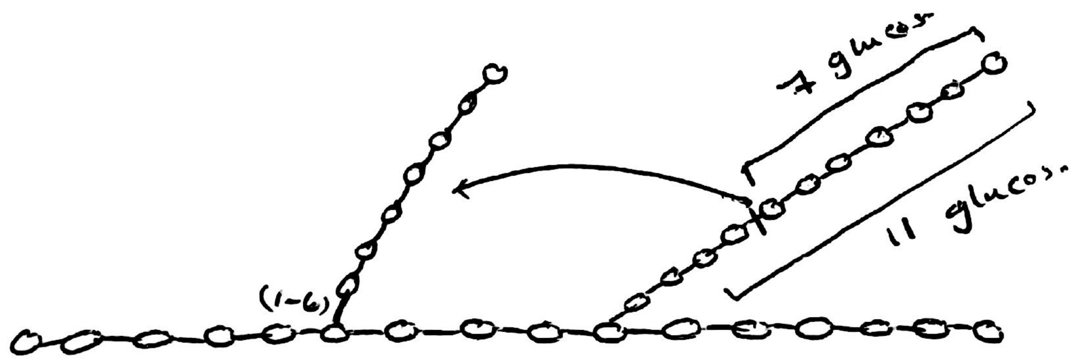
Then,

Glycogen Synthase Can work by adding more glucose α(1-4)

Branching Step : by branching Enzymes

① transfer 7 glucose from the end of glycogen chain « should be at least 11 glucose »

② form a new branch by α(1-6), But بشرط each branch point at least 4 glucose away from the other branch



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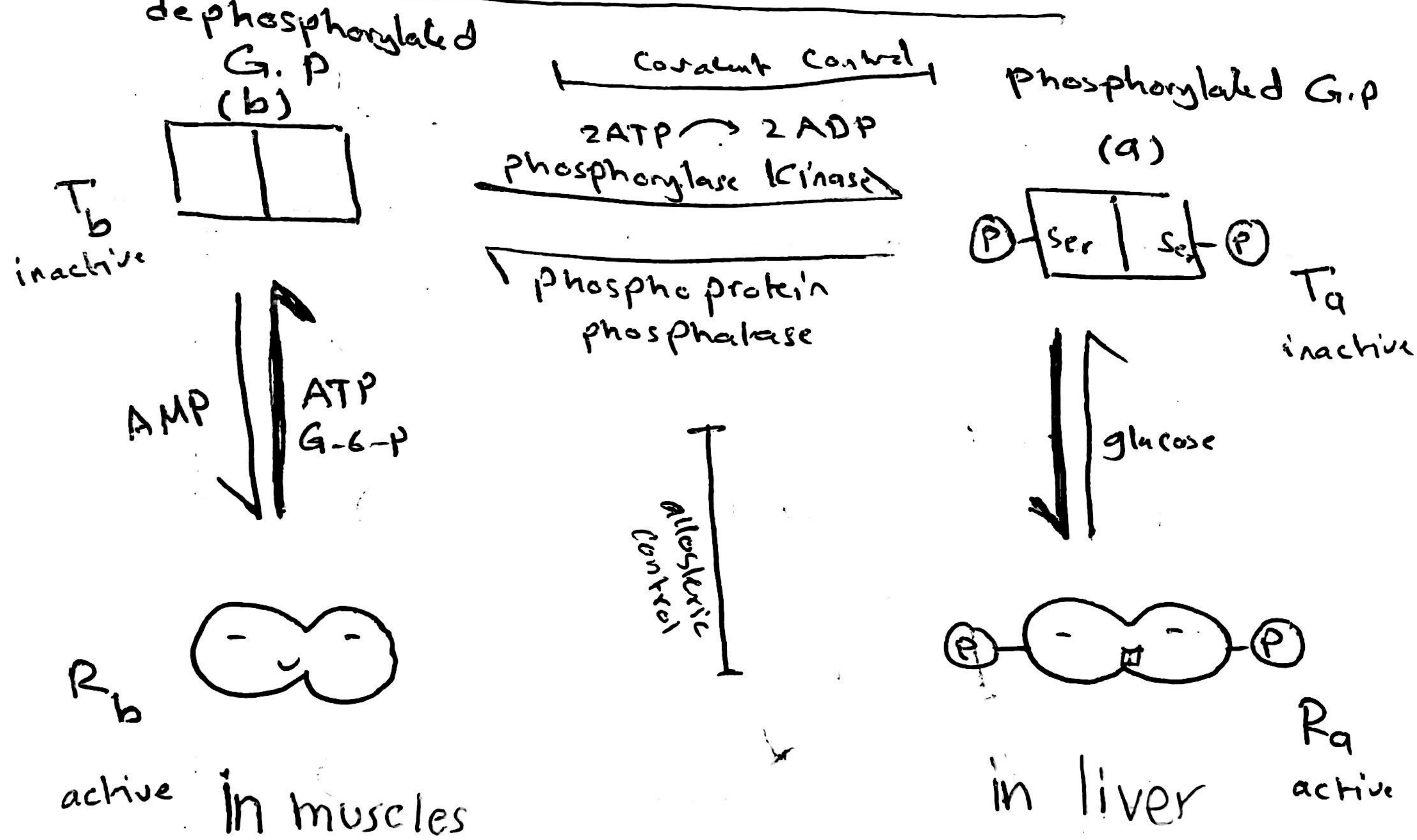
Glycogen Phosphorylase [Dimer, 2 subunits 1]
Control

- Allosteric
- Covalent الاهم
- Hormonal << glucagon + Epinephrine >> (Adrenalin نفسه)

glucagon + Epinephrine → +ve
<<insulin>> → -ve



* Glycogen phosphorylase a is more active than Glycogen phosphorylase b.

⇒ Covalent Control is the major form of Control

→ allosteric control for Fine tuning (تعديلات بسيطة)

In muscles AMP will activate phosphorylase b and ATP, glucose 6-P will inhibit phosphorylase b

In liver glucose will inhibit phosphorylase a

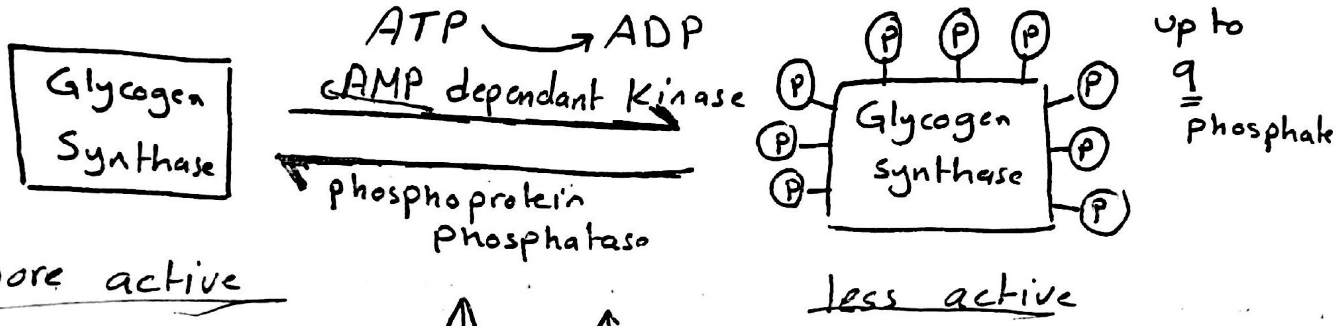
T form and only T can be modified by phosphorylation on serine.

* Response of phosphorylation within seconds to minutes, while response to Allosteric within milliseconds.

Allosteric control = faster
Covalen control = stronger

Glycogen Synthase

* Allosteric
* Covalent
* Hormonal « Glucagon, Epinephrine » (−ve) « insulin » (+ve)



↑Amp ↑ phosphate

* Allosteric Control
  - if ↑ Glucose-6-(P) ⇒ +ve (activation)
  - if ↑ ATP ⇒ −ve (inhibition) !!? (موجودة في الكتاب مع أنها غير منطقية)

* Glycogen Synthase-(P) the phosphorylated Glycogen synthase only active unde very high level of Glucose-6-(P) So it is called Glycogen Synthase D (dependant)

* Glycogen Synthase the dephosphorylated Glycogen synthase, active even with low level of glucose-6-(P) So it is called Glycogen Synthase I (Independant)

* • Glucagon and Epinephrine stimulate phosphorylation of Glycogen Synthase (Inhibition)
  • Insulin stimulate dephosphorylation (activation)

* as phosphorylation level increase, Glycogen Synthase activity decrease

...tose phosphate pathway (PPP)
or Hexose monophosphate Shunt
or Phosphogluconate Pathway

* alternative to glycolysis

what is the importance of pentose phosphate pathway?

Production of
① 5-Carbon Sugars
Ex: ribose < DNA, RNA

② NADPH : reducing agent, important in Lipid metabolism

* pentose phosphate pathway divided into 2 Phases
- → Oxidative phase (Irreversible)
- → Non-oxidative phase (reversible) اعادة ترتيب ذرات فقط

Phase I

Glucose
↳ Glucose - 6 - Ⓟ (First intermediate) —— Glucose-6-P. dehydrogenase ——→ 6-phosphogluconate (second intermediate)
NADP⁺ → NADPH

6C
6-phosphogluconate —— 6-phosphogluconate dehydrogenase ——→ Ribulose - 5 - phosphate (third intermediate) + CO_2
خماسي (Ketose) - 5C
NADP⁺ → NADPH

→ « oxidative - decarboxylation »

(a)

...se II

Ribulose-5-(P) (Ketose) ⇌ Ribose-5-(P) (Aldose)
phosphopentose isomerase

Ribulose-5-(P) ⇌ Xylolose 5-(P) (Ketose)
phosphopentose 3-Epimerase

Ribulose and Xylolose are epimers on C_3

بتسمحنا بأخذ:
3 سكريات خماسية

5C Ribose-5-(P)
5C Xylolose-5-(P)
5C Xylolose-5-(P)

ويحولهم إلى
سكرين سداسيين وسكر ثلاثي

6C Fructose 6-(P)
6C Fructose 6-(P)
3C glyceraldehydrate 3-(P)

using (work like scissors)
of transketolase (transfer 2C)
of transaldolase (transfer 3C)

Xylolose-5-(P) + Ribose-5-(P) ⇌ (transketolase; 2C) $C_3 + C_7$

$C_3 + C_7$ ⇌ (transaldolase; 3C) $C_6 + C_4$ (C6 أو)

C_4 + Xylolose-5-(P) ⇌ (trankelolase; 2C) $C_6 + C_3$

أسماء الكربونات

C_3: Glyceraldehyde 3-(P)
C_6: Fructose 6-(P)
} go to glycolysis

C_7: Sedoheptolose-7-(P)
C_4: Erythrose-4-(P)

* Both transketolase and transaldolase transfer Carbon from Ketose to aldose

*ransaldolase similar to aldolase (aldol condensation & cleavage)

* Transketolase similar to pyruvate (الرحمن) decarboxylase
  → also need - Mg^{+2}
  - TPP (B_1)

Control: * If the organism needs NADPH more than pentose sugar, we go through oxidative phase (PPP occurs completely)

* If the organism needs pentose sugar more than NADPH, we go through non-oxidative phase but in reverse direction (these are reversible)

2 Fructose 6-Ⓟ + Glyceraldehyde 3-Ⓟ ⟹ Xylolose-5-Ⓟ, Xylolose-5-Ⓟ, Ribose-5-Ⓟ

Best wishes
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During the pentose phosphate pathway (Glucose-6-P → Ribose 5-P) is there a net oxidation of the substrate carbon atoms?

a. yes

b. NO

c. It depends on whether the process is under aerobic or anaerobic

d. It depends on the species doing the process

e. It depends whether the glucose goes through the oxidative part of the pathway or not.

Q: The enzyme phosphopentose isomerase is characterized by all of the following Except:-

a. it catalyzes the interconversion of ribose 5-Ⓟ and ribulose 5-Ⓟ

b. there is no requirement of ATP

c. it converts a Ketose to aldose

d. it catalyzes an inversion of configuration on Carbon-3

Q: In addition to pentoses, the pentose phosphate pathway involves sugars of all of these sizes except:-

a. 3 carbons

b. 4 carbons

c. 6 carbons

d. 7 carbons

e. all of these sizes are used in this pathway

TPP is important in transferring all of these types of groups, except:-

a. 2 Carbon Sugar fragments

b. 3 Carbon Sugar fragments

c. 4 Carbon Sugar fragments

d. Sugar fragment which contain Carbonyl-group (c=o)

e. TPP can transfer all of these types of groups

Q: All of the following sugar arrangments are part of pentose phosphate pathway except:-

a. $C_5 + C_5 \longrightarrow C_7 + C_3$

b. $C_5 + C_5 \longrightarrow C_6 + C_4$

c. $C_7 + C_3 \longrightarrow C_6 + C_4$

d. $C_5 + C_4 \longrightarrow C_6 + C_3$

e. all of these arrangments occurs in pentose phosphate pathway