Bacteria

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Advantages of operon

- Allow bacteria to coordinately regulate the expression of a group of genes that encode proteins with a common functional goal
- Ensure that all proteins necessary to metabolise a particular compound are under a single promoter so that these genes are made turned off or turned on at the same time helping the bacteria to respond quickly to environmental changes (how operons allow for rapid response by bacteria to environmental change), providing a selective advantage
- Bacteria only produces enzymes when required, preventing waste of limited energy and resources which provides a selective advantage as they are able to respond quickly to changes in environment
- Different operant allow bacteria to utilise different types of carbon source/ a variety of sugars for their energy requirements

For repressible systems only:

- When end product is abundant, synthesis would stop and operon can be repressed to minimise wastage and conserve resources and these resources can be redirected to other cellular processes important to bacterium

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How does lac operon works/ how the metabolism of lactose in bacterial cells is regulated

- Regulation of the metabolism of the lactose is done by lac operon With Lac ZYA under the control of one promote sequence which codes for enzymes/

proteins that hydrolyse lactose to allolactose(lac Z) and transport lactose into the cell (lac Y)

- Lac L gene codes for an active lac repressor which is complementary in shape and binds to the operator sequence, a repressor binding site
- When lactose is absent, there is basal transcription level as repressor is bound to the operator sequence, inhibiting RNA polymerase from binding to promoter
- When lactose is present and glucose is absent, lactose is transported into the cell by permease and is converted to allolactose by beta-galactosidase
- Allolactose acts as an inducer and binds to the allosteric site of lac repressor and changes the conformation of active lac repressor thereby inactivating it as it is no longer complementary to the operator sequence and thus dissociates from operator, no longer can bind to the operator
- This allows the binding of RNA polymerase to promoter and move downstream to transcribe the structural genes to form beta galactosidase, permease and transacetylase for metabolism of lactose
- ATP converted to cAMP by adenyl Cyclase and cAMP binds to Catabolite Activator Protein (CAP) to form cAMP-CAP complex activating it which then binds to the CAP site upstream of promoter, increasing expression of Lac operon as it increases the affinity of RNA polymerase to promoter (relate to cell signalling where low glucose causes glucagon to bind to GPCR, eventually activating adenyl Cyclase)
- When glucose is present, it inhibits adenyl Cyclase which is responsible the conversion of ATP to cAMP, low levels of cAMP, lesser cAMP to bind to CAP, to form cAMP-CAP complex amd activating it, lac expression at basal level

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Binary fission significance

- Results in the production of genetically identical daughter cells thus gene that codes for desirable traits are passed on to daughter cell favouring success colonisation
- It is a form of asexual reproduction in bacteria and hence it is a fast process allowing rapid reproduction of bacteria

- Short generation span helps in the accumulation of mutations and evolution process

benefits of conjugation

- they may receive genes that codes for antibiotic resistance
- They may receive fences that codes for enzymes not originally present, giving them the ability to use a new metabolite
- They may receive genes that codes for xenobiotic resistance (substances that are foreign)

How does prokaryotic genome have variation yet preserved

Preserved

- ref to mechanism of proper separation
- Ref to semi-conservative DNA replication
- Ref to two genetically identical daughter cells

Variation

Conjugation:

- F+ cell forms a mating bridge with F- cell
- One strand of DMA of F plasmid breaks, peeks off and enters F- cells
- Unbroken strand of F plasmid in F+ cell serves as a template to synthesise the new strands , reforming the double stranded F plasmid
- The transferred plasmid strand that enters the F- cell serves as as a template for synthesis of new strands, molecule circular it’s to form New F plasmid

Compare eukaryotic and prokaryotic genome

Features	Eukaryotes	Prokaryotes
Shape	Linear molecule	Circular molecule
Amount	Multiple	Singular

Features	Eukaryotes	Prokaryotes
Level of DNA packing	Forms a nucleosomes	Folds into chromosomal looped domains by protein-DNA association
Protein associated with packing	Histone association	Loop around histone like proteins
Location	Nucleus surrounded by nuclear envelope	Nucleoid region, not-membrane bound
Origin of replication	Many	One

- both have promoters
- Double helix dna

Role of F plasmid

- F factor on f plasmid codes for proteins necessary for the formation of the sex puli and subsequent cytoplasmic mating bridge allowing for conjugation to occur between bacteria
- Allows bacterial genes to be transferred between bacteria and hence increases genetic variation between bacteria

Structural and regulatory genes

- Lac Z, lac Y and lac A are structural genes that codes for protein products that has an enzymatic function in a metabolic pathway
- Lac I gene is a regulatory genes that codes for a protein such as a repressor involved in regulating expression of structural gene

How DNA is arranged in eukaryotes and prokaryotes

- Eukaryotic DNA coils around proteins called histone s to form nucleosomes followed by coiling around itself to form solenoid which will associate with scaffold proteins forming looped domains

- Supercooling of loops to condense into the metaphase chromosome
- Prokaryotic DNA associated with relatively fewer proteins to form loops and there is supercooling to cause further compaction

Describe a feature of operon/ prokaryotic transcription

- Genes coding for protein involved in the same biochemical pathway usually clustered together on one operon under a single promoter
- If repressor is active it binds to the operator which overlaps with the promoter and prevent the RNA polymerase from binding to the promoter thus preventing transcription

Account for population growth of bacterium grown in limited concentrations of glucose and lactose

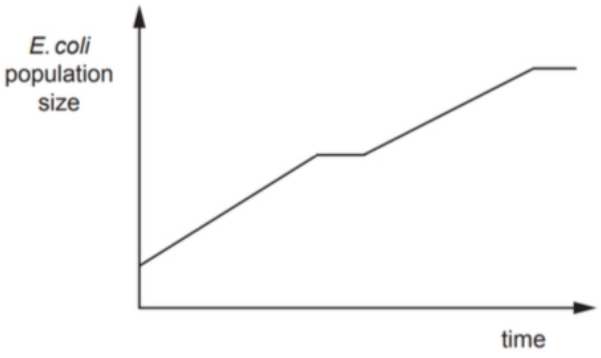

Fig. 6.3

- Population size initially increases as bacterial cells are utilising glucose for cellular respiration in order to produce ATP during glycolysis and oxidative phosphorylation to provide energy for binary fission
- Population size levels off when glucose depletes and bacteria take time to activate lac operon to produce beta galactosidase
- Population size in eases again as bacterial cells are hydrolyse lactose into glucose and galactose to utilise the glucose
- Population size levels off again as lactose is depleted

Explain what is meant by an operon

- It is a functioning unit consisting of a promoter, operator, cluster of structural genes and a terminator
- The cluster of structural genes encodes gene products that function in a common pathway and the genes transcribed together give a polycistronic mRNA

Describe the molecular basis of or the inhibition of lac operon

- controlled by negative gene regulation
- Lac I gene codes for lac repressor protein, synthesised in its active form in absence of lactose
- Active repressor binds to operator region of lac operon, preventing RNA polymerase from binding to the promoter
- Structural genes lac Z Y and A not transcribed

Describing horizontal gene transfer (gene transfer between different cells)

Conjugation:

- Sex pilus of F+ bacterial cell makes contact with F- bacterial cell amd retracts to bring the F- cell closer so a mating bridge is formed between the 2 cells
- One of the 2 strands of the plasmid DNA in F+ cell is nicked and transferred from the F+ cell to F- cell through a cytoplasmic mating bridge via rolling circle mechanism as the other DNA strand is used as a template for elongation
- The single strand F plasmid DNA circularises in F- cell and is used as a template to synthesise a complementary strand for a double stranded F plasmid DNA resulting in F+ cell

Generalised transduction:

- A phage infects bacterium, injecting its viral genome into host cell
- Bacterial DNA is degraded into small fragments one of which may be randomly packaged into a capsid head during spontaneous assembly of new viruses

- Upon cell lysis, defective phage infects bacterium another bacterium and injecting bacterial DNA from previous host cell into new bacterium
- Foreign bacterial DNA can replace homologous region in recipients cells chromosome if crossing over takes place, allowing expression of a different allele from previous host

Specialised transduction:

- A temperate phage infects a bacterium, injecting its viral genome into host cell
- Viral dna integrated to bacterial chromosome forming a prophage which may be improperly excised to include adjacent segment of bacterial dna during an induction event
- Bacterial DNA may be packaged into a capsid head during spontaneous assembly of new viruses
- Upon cell lysis defective phage infects bacterium another bacterium and inject bacterial DNA from previous host cell into new bacterium
- Foreign bacterial dna can replace homologous region in recipient cells chromosome if crossing over occurs, allowing expression of a different allele from previous host

Describe what happens during lateral gene Transfer (binary fission)

- Bacterial genome which is made of circular DNA replicates by semi conservative replication
- DNA is unzipped by breaking hydrogen bonds between bases of 2 strands and each parental strand serves as a template for synthesis of daughter strands
- Free deoxyribonucleotides complementary base pair with bases on parental strand
- DNA polymerase forms phosphodiester bonds between adjacent deoxyribonucleotides

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Compare asexual reproduction with binary fission in bacteria

- both produce 2 genetically identical daughter cells

- Budding involves the evagination of cell surface membrane to form a daughter cell in asexual reproduction but binary fission involves the invagination

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Compare lac operon and trp operon

- Both consist of several genes under the control of a single promoter
- Both have an operator region for the binding of an active repressor that prevent transcription
- The gene codes for enzymes involve in the same metabolic pathway or functionally related proteins are synthesised as a unit
- Each operon when expressed produce a polycistronic mRNA that has several start and stop codons

Features	Lac Operon	Trp Operon
Type of operon	Inducible operon that is switched on in the presence of an inducer lactose	Repressible operon that is switched off in the presence of excess end product tryptophan
Effector molecule	Inducer is lactose which is the substrate	Corepressor tryptophan an end product
Repressor synthesised In	Active	Inactive
Condition affecting repressor	Allolactose binds to and inactives the repressor such that it cannot bind to the operator	Tryptophan binds to and activates the repressor such that it can bind to operator
Type of metabolic pathway	Enzymes produced involved in a carbolic process of breaking down lactose	Enzyme produces involved in an anabolism process of synthesising tryptophan
Default operon expression	Operon is switched off by default until presence of lactose	Operon is switched on by default until tryptophan is in excess
Number of genes or proteins coded	Lac operon codes for 3 different enzymes	trp operon coded for 5 different enzymes