

## Exam #3 Review

Exam #3 will cover from gene expression to antimicrobial chemotherapy. This includes the Central Dogma of Gene Transfer in prokaryotes (replication, transcription and translation), eukaryotic gene expression, regulation of gene expression (the *lac* operon), bacterial genetics and antibiotics.

### I. Nucleic acids and gene transfer

\*Make sure that you are comfortable with the difference between replication, transcription and translation.

A. The **genome** of a bacterial cell includes both the DNA of the chromosome and that of the plasmids.

*The following exercise will help you review and better understand the concepts covered in class:*

*Draw the structure of DNA. Be sure to include the 5'-phosphate and the ribose sugar. Simply depict the bases by their letter code. Indicate the 3' and 5' ends of each strand and show the H-bonds and the antiparallel nature of the two strands.*

1. When the H-bonds between two DNA strands break = **denaturation** or **melting**.

2. Because of the base-pairing rules, one strand of DNA can always be used as the template for the synthesis of another.

*Practice: In a DNA molecule*

*a. there are two antiparallel strands of nucleotides; these strands are joined together by hydrogen bonds. One of the nucleotide strands runs in the 5' to 3' direction and the other runs in the 3' to 5' direction.*

*b. , because of the rules of base pairing, one of the strands of DNA can always serve as the template for the synthesis of the other strand.*

*c. the hydrogen bonds holding the strands of nucleotides together can be broken in a process called denaturation or melting.*

*d. all of the above.*

*Practice: In what ways is RNA different than DNA?*

B. DNA can be transcribed to give three different types of RNA. The one that we most commonly think about is **mRNA**. This type of RNA is simply a messenger and it is always translated to give a protein product. In contrast, neither **rRNA** nor **tRNA** are ever translated. Instead they have very important functions as RNA. rRNA plays a very important role in the translational function of the ribosome. tRNA binds to amino acids and delivers them to the ribosome where the polypeptide chain (that will fold into a protein) is being translated from the mRNA code.

### Practice: Only mRNA, but not rRNA or tRNA

- a. is composed of ribonucleotides.
- b. is formed when DNA is transcribed.
- c. serves a functional purpose within the cell.
- d. is translated to form protein product.
- e. all of the above

### C. Replication

1. Replication of a circular chromosome or a plasmid always begins at a point on the plasmid called the origin of replication. Replication proceeds from this point in both directions (it is **bidirectional**).

**Practice: Without using your notes, try to draw the general replication process (depict the entire plasmid). Be sure to label the replication forks and use a different color to represent newly synthesized DNA. This will help you to see that replication is semi-conservative, that is, both the final DNA molecules contain one of the original strands and one of the newly synthesized strands.**

#### Replication of the *E. coli* chromosome

- a. initiates when an RNA polymerase enzyme called Tus unwinds a short stretch of DNA.
- b. originates and terminates at the same location.
- c. results in the transient formation of a region of newly synthesized DNA called the replication bubble.

2. Details of the process:

a. Before replication begins, **helicases** unwind the helix and **topoisomerases** relieve the tension.

b. At the replication fork, a single complex called the **replisome** (containing **DNA polymerases**) synthesizes BOTH THE LEADING AND LAGGING STRANDS.

c. Because it is a single complex responsible for synthesis of both strands and because DNA polymerase can only synthesize DNA in the **5' to 3' direction**, only one strand of newly synthesized DNA at the replication fork can be synthesized continuously (the **leading strand**). The other strand must be synthesized discontinuously (the **lagging strand**). The first step in the synthesis of the lagging strand is the formation of small RNA primers by the enzyme called **primase**. In the next step, DNA polymerase recognizes the free 3'OH ends of these small primers. It then builds DNA between primers forming **Okazaki fragments**. A second DNA polymerase removes the RNA primers and replaces them with DNA. Finally **DNA ligase** seals the nicks between the fragments. Be sure that you understand that DNA polymerase requires a primer in order to begin synthesizing DNA. (It sees a free 3'OH as its starting point.) Even the leading strand initially begins with a small RNA primer.

**Practice: Based on the following illustration, which deoxynucleotide would DNA polymerase add next to the currently synthesizing strand (bottom strand)?**



- a. dATP
- b. dGTP
- c. dTTP
- d. dCTP
- e. dPCP

**Practice: Which of the following is/are true about DNA replication?**

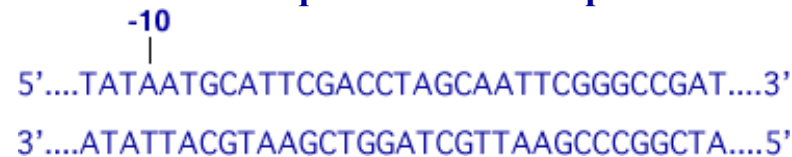
- a. It starts at the origin of replication.
- b. It is bidirectional
- c. It requires an RNA primer to get started.
- d. It is semiconservative.
- e. All of the above.

#### **D. Transcription (DNA to RNA)**

1. By convention, the top strand of DNA is always depicted in the 5' to 3' direction. It is called the **coding** or **plus** strand. The bottom strand is thus antiparallel to the coding strand. This strand is the strand that will actually serve as template for the synthesis of RNA. Thus the bottom strand is termed the **template** or **minus** strand. Because the lower strand serves as template for RNA synthesis, the RNA will always look like the plus (coding) strand except that it will be made of ribonucleotides instead of deoxyribonucleotides and U will replace T!

#### **IMPORTANT PRACTICE QUESTION:**

**Observe the following region of DNA, and notice the location of the TATA box sequence within the promoter.**



**What is the sequence of the RNA transcript for the portion of the gene shown here?**

- a. 5'AAUGCAUUCGACCUAGCAAUUCGGGCCGAU...3'
- b. 5'ACCUAGCAAUUCGGGCCGAU....3'
- c. 5'ACCTAGCAATTCGGGCCGAT....3'
- d. 5'AATGCATTCGACCTAGCAATTCGGGCCGAT....3'

**It is important to understand that the template strand of DNA is used as the code to build the RNA. Therefore, the RNA looks like the coding strand of DNA except all Ts are replaced by Us.**

2. The **promoter** is the transcription initiation site. In prokaryotes, there is often more than 1 gene under control of the same promoter. This is called an **operon**. All of the genes under control of this same promoter will be transcribed to give a single RNA (a polygenic or **polycistronic RNA**). In eukaryotes, generally every gene has its own promoter. Promoters are consensus sequences of nucleotides that lie **upstream** of the gene: The **-35 region** and the **TATA box**.

## 2. INITIATION

The **sigma factor** is the subunit of **RNA polymerase** that recognizes the promoter. Once RNA polymerase has melted and unwound a short stretch of DNA (forming the transcription bubble), and synthesized a short stretch of complementary RNA, the sigma factor dissociates from the rest of the RNA polymerase enzyme (the core enzyme) and transcription continues.

**Practice: Which of the following is/are involved with the initiation phase of transcription but not with elongation or termination?**

- a. RNA polymerase
- b. the sigma factor
- c. the promoter
- d. the hairpin loop
- e. both b and c
- f. both a and d

**Practice: (T or F) RNA polymerase requires a primer in order to begin transcription.**

## 3. ELONGATION

RNA polymerase adds one ribonucleotide at a time as according to the DNA template strand. **\*\*Note:** as the RNA strand is synthesized it dissociates from the template strand and the template strand reanneals with its original complementary DNA strand (the plus strand).

**Practice: (T or F) A DNA template strand can be transcribed by more than one RNA polymerase enzymes at a time.**

**Practice: Which terminal of the mRNA transcript is readily available while transcription is still taking place (the 5' or the 3')?**

## 4. TERMINATION

There are two different types of termination:

- a. Termination due to hairpin loop formation
- b. Rho-dependent termination

## I. Translation (RNA to Protein)

*Practice drawing an amino acid. Show how a second amino acid would bond to this amino acid at the carboxyl terminal. Continue drawing, depicting how one amino acid after another would add to the carboxyl terminal to form a polypeptide chain! This will not be an exam question but it's essential to be able to visualize the process in order to understand translation.*

1. A **codon** is a 3-nucleotide sequence. There are 64 possible codons, 3 of which are **stop codons**: UAA, UAG and UGA and 61 of which encode for different amino acids. **(PLEASE do not attempt to memorize all 61 codons and the amino acids for which they encode! I will provide a copy of the table in your notes.)**

Since there are only 20 amino acids, it must be true that more than one codon can specify the same amino acid = **degeneracy**.

(Note- AUG is the start codon, however, it is only the start codon (encoding for f-Met) the first time it is encountered after the ribosome binding site (Shine-Dalgarno sequence). In all other locations, this codon simply codes for the amino acid methionine.)

**Practice: Which statement/s regarding prokaryotic translation is/are TRUE?**

- a. Only the coding region of an mRNA transcript is translated to make protein.
- b. The codons UUU, UUC and UUA all encode for the same amino acid.
- c. More than one codon specifies the amino acid Val.
- d. all of the above
- e. a and c

2. Ribosomes:

The factories in which translation occurs. They stabilize the mRNA and tRNAs such that the codons of the mRNA can be read 5' to 3' and the corresponding tRNAs can deliver the correct amino acids. The ribosome then catalyzes the linkage of adjacent amino acids to eventually form a polypeptide chain.

3. tRNAs

have an amino acid binding site as well as a 3-nucleotide **anticodon**. The anticodon recognizes the codon and thus allows the tRNA to deliver the correct amino acid to the ribosome where the mRNA is being read and the polypeptide chain is being built.

tRNAs can recognize more than one codon = **“wobble” (How does this relate to degeneracy?)**

**Practice: A tRNA with an anticodon sequence of 3'ACG 5' would recognize which codon and carry which amino acid?**

**\*\*VERY IMPORTANT CONCEPT\*\***

4. INITIATION

\*Note- Please be certain that you understand the difference between the **Shine-Dalgarno sequence**

**(ribosome binding site)** and the **start codon**. The ribosome binding site is generally ~7 nucleotides upstream from the start codon. Translation does not begin until the start codon. I will often represent the ribosome binding site as a black box but please understand that it is actually a particular sequence of purine-rich nucleotides.

\*\*Also note that in prokaryotic cells translation can begin even before transcription is complete. **Why can't this occur in eukaryotic cells??**

## 5. ELONGATION

**Practice: Which one of the following correctly summarizes the order of events that take place during the elongation phase of translation?**

- 1. The initiating tRNA carrying the f-Met residue is bound in the P-site.**
- 2. The ribosome advances the distance of one codon along the mRNA and the initiating tRNA + f-Met leave through the E-site.**
- 3. The f-Met residue is covalently bound to the amino acid carried by the tRNA in the A-site.**
- 4. A tRNA carrying the amino acid that corresponds to the second codon binds to the A-site.**

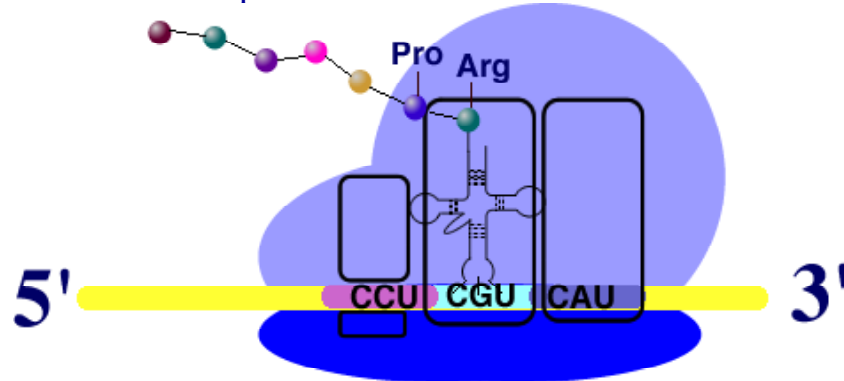
- a. 1, 2, 3, 4**
- b. 1, 3, 4, 2**
- c. 1, 4, 3, 2**
- d. 4, 1, 3, 2**

\*Note: The same RNA can be translated by several ribosomes at once = a **polysome** or **polyribosome**.

**Practice: In which direction is the polypeptide chain synthesized?**

- a. from the carboxyl terminal to the amino terminal.**
- b. from the amino terminal to the carboxyl terminal.**

Practice: Shown below is an prokaryotic mRNA transcript and the polypeptide that results as this transcript is translated. Which statement/s is/are TRUE?



- a. arginyl-tRNA<sup>Arg</sup> is bound at the P-site.
- b. The amino acid that will be added next to the chain is His.
- c. In this snapshot picture shown, translation is currently in the elongation phase.
- d. all of the above**
- e. b and c

#### 6. TERMINATION

When the ribosome reaches a stop codon, **release factors** break the bond between the tRNA and the final amino acid in the polypeptide chain -> translation is terminated. The ribosome falls off the mRNA and dissociates into its subunits.

**CAUTION:** Often it is easy to feel comfortable with the principles and processes of replication, transcription and translation. However, I find that it is more difficult when trying to answer questions that ask one to relate the three:

**Practice: Which of the following is / are involved in replication?**

- a. RNA polymerase
- b. sigma factor
- c. DNA polymerase
- d. The Aminoacyl(A)-site
- e. The promoter

#### I. eukaryotic gene expression

**Practice: Which statement about eukaryotic and prokaryotic gene expression is FALSE?**

- a. In eukaryotic cells only, the 5' end of the mRNA transcript is "capped" by the addition of a methylated guanine derivative.
- b. In eukaryotic cells more often than prokaryotic cells, approximately 200 adenines are added to the 3' end of the mRNA transcript.
- c. Generally only eukaryotic genes have both coding



- (exons) and noncoding (introns) regions.
- d. Only prokaryotic mRNAs must be transported out of the nucleus before they can be translated.
- e. eukaryotic mRNAs are usually monocistronic whereas prokaryotic mRNAs can be either monocistronic or polycistronic.

## II. Regulating gene expression

A gene that is always expressed = **constitutive**. Some genes are usually off but can be turned on (induced) while other genes are usually on but can be turned off (repressed).

### A. Mechanisms to control gene expression

#### **Practice: What is an operon?**

##### 1. PROMOTER SEQUENCE:

The closer a promoter sequence is to the ideal consensus sequence, the more frequently it is transcribed.

##### 2. SPECIALIZED SIGMA FACTORS:

Certain sigma factors are only produced under specialized situations and they recognize and bind to specialized promoters, allowing for expression of genes that are only needed under unique environmental conditions. This is one of the mechanisms used to control the expression of genes involved in endospore formation.

##### 3. MODULATION BY DNA BINDING PROTEINS:

A **repressor** blocks transcription by binding to an **operator**. An **activator** facilitates transcription by binding to an **activator binding site**.

Repressors and activators are allosteric proteins themselves. Thus, other molecules can bind to them and affect their ability to bind to the DNA:

- Some repressors can't bind to the operator site until another molecule (called a **corepressor**) binds to them and allows them to bind to the operator and block transcription (e.g. the *trp* operon).
- Some repressors bind to the operator site and block transcription until another molecule (called an **inducer**) binds to the repressor and keeps it from binding to the operator site (e.g. the *lac* operon).
- Some activators cannot bind to the activator binding site until another molecule (called an inducer) binds to them (e.g. the *lac* operon).

B. **\*\*The *lac* operon** demonstrates many types of regulation. It is under control of both an activator and a repressor:

**Practice: In lab, we inoculated a KIA tube with *E. coli*.**

**Remember that a KIA tube contains both glucose (in short supply) and lactose (in excess). What type of growth occurs in this tube during an overnight incubation? Explain all of the**



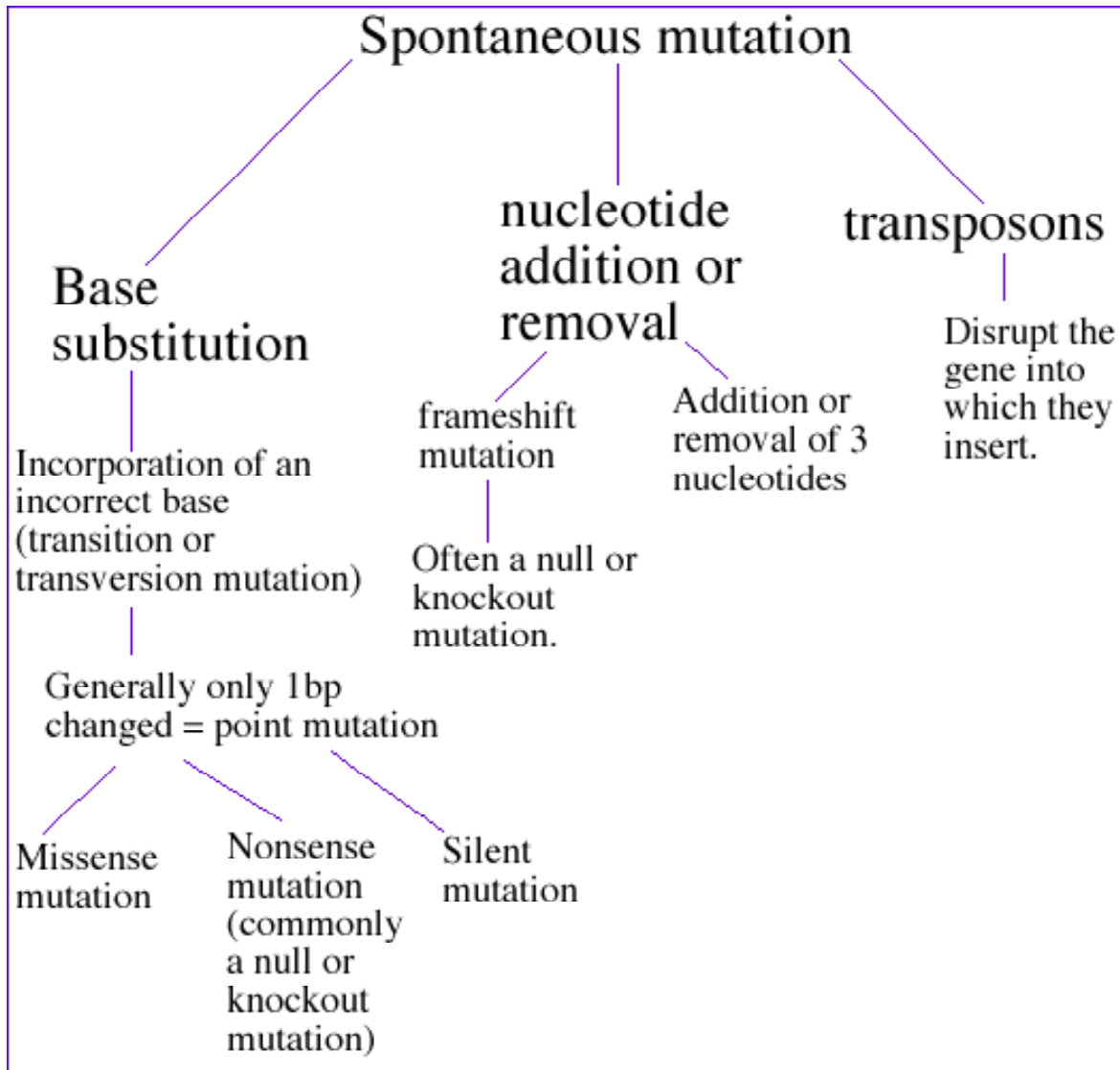
**changes that occur on the *lac* operon during this incubation. (\*A QUESTION OF THIS VARIETY WILL DEFINITELY BE ON THE EXAM. MAKE CERTAIN THAT YOU ARE COMFORTABLE DETERMINING HOW ENVIRONMENTAL CONDITIONS TELL YOU THE STATE OF THE *lac* OPERON!)**

IV. Bacterial Genetics

A. Genetic diversity created by changes in genotype

**Practice: What are two mechanisms by which the genotype of an organism can change?**

1. Mutation



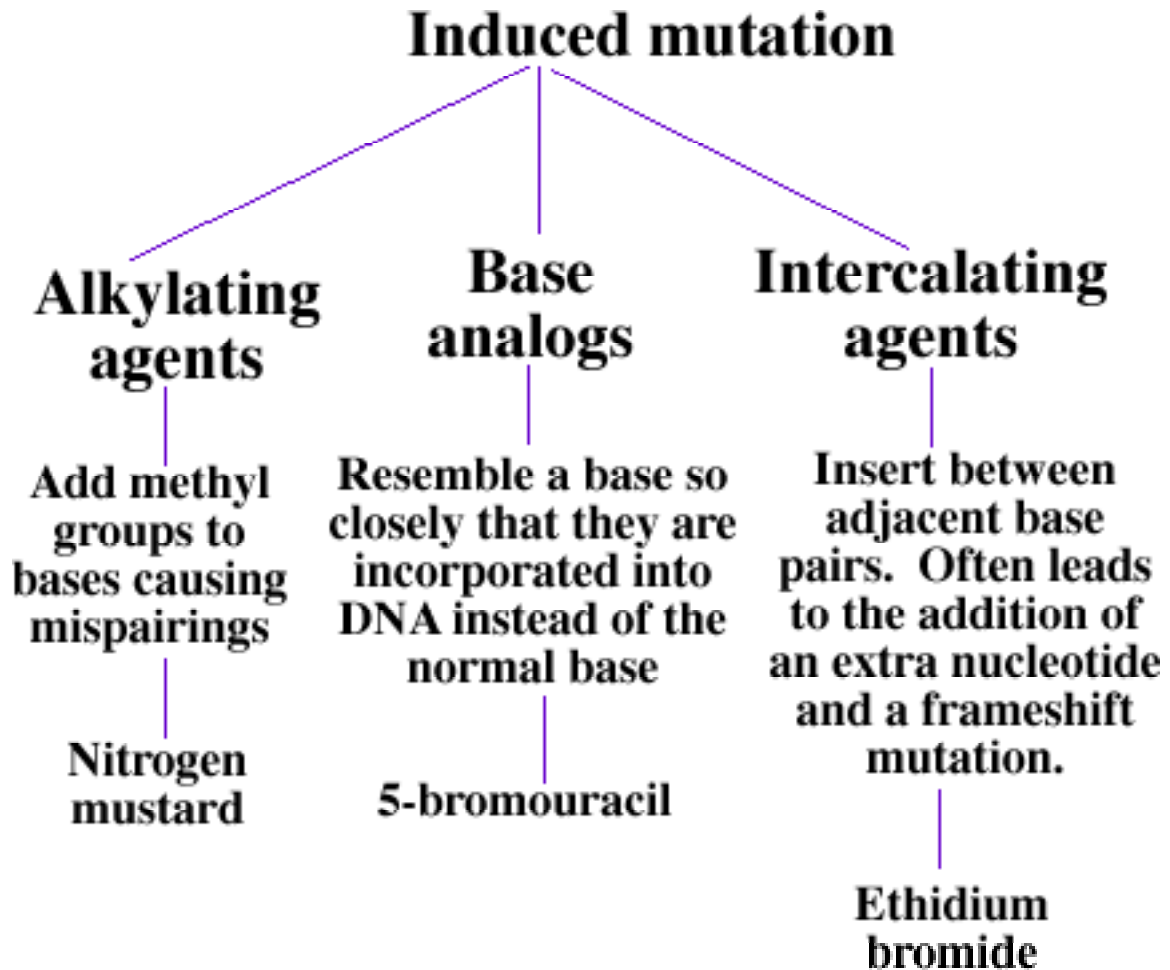
**What is a neutral mutation?**

**\*\*Revisit questions 16-18 on Homework Set 8\*\* \*\*These are IMPORTANT QUESTIONS. A QUESTION OF THIS VARIETY WILL DEFINITELY BE ON THE EXAM!**

**Practice: After a base substitution, is a stable mutant formed in the first generation?**

**If a mutation occurs in an essential gene and causes death under certain conditions but not others, what is it called?**

**\*What are some other problems caused by transposons??**



Note - Nitrosoguanidine causes GC to AT transition mutations whereas, 5-bromouracil causes AT to GC transition mutations.

**\*Note - mutations as listed above under spontaneous mutation can also be induced by mutagens!**

2. Mutants

**Practice: Mutations are not always harmful to an organism, in fact, sometimes they provide a selective advantage. What are two types of selective advantages made possible by mutation?**

a. Mutations can be detected in three ways:

- 1) By observation if they cause a visible change in phenotype.
- 2) By **direct selection** if the mutant will grow in the

presence of some substance that the wild type cells will not grow in the presence of (e.g streptomycin resistant mutants)

3) By **indirect selection** if the mutant is an **auxotrophic** mutant and needs something for growth that the **prototrophic** cells do not need. Understand replica plating = an example of an indirect selection method.

**Practice: An organism that is Trp<sup>-</sup>**

**a. is unable to synthesize the amino acid tryptophane.**

**b. will grow on a GSA plate.**

**c. is a prototroph**

**d. has a *trp<sup>+</sup>* genotype.**

b. The **Ames Test** identifies potential carcinogens by testing chemicals for their ability to cause mutation in a bacterial system. The particular bacterial system used is a His<sup>-</sup> auxotroph of *Salmonella*. Chemicals that can cause this auxotroph to revert to the prototroph are mutagens and considered potential carcinogens.

**Practice: A student doing his summer internship at Rocky Mountain Labs, performs the Ames Test on a chemical thought to be a potential carcinogen. After incubating the GSA plate, the student notes that there are many more colonies on the plate than are seen on a negative control plate. Which conclusion/s does the student make?**

**a. The chemical tested is a potential carcinogen.**

**b. The chemical tested is not a potential carcinogen.**

**c. The chemical tested is a mutagen.**

**d. The chemical tested is not a mutagen.**

**e. a and c**

**f. b and d**

## **2. Horizontal gene transfer**

The donor DNA called the exogenote enters a recipient cell via one of the three mechanisms of lateral gene transfer: transformation, transduction or conjugation. The exogenote DNA may become a stable part of the recipient's genome (called the endogenote) forming a **recombinant** cell.

**Practice: Transformation, transduction and conjugation**

**a. all involve a horizontal gene transfer.**

**b. all involve an F-pilus.**

**c. all require cell-to-cell contact.**

**d. all involve a bacteriophage.**

**e. a and b**

**f. a, b and c**

\*Note - During any recombination event, DNA is transferred, unidirectionally, to no more than a small fraction of the potential

recipient cells.

**a. Transformation**

**Practice: Which statement/s describe/s DNA-mediated transformation?**

- a. The uptake of “naked” DNA. The DNA can be either a plasmid or a linear piece of DNA.**
- b. A horizontal gene transfer.**
- c. The transfer of DNA from one cell to another by a bacteriophage.**
- d. The process by which a cell is transduced.**
- e. a and b**
- f. b and c**

**Practice: Which statement/s about DNA-mediated transformation is/are FALSE?**

- a. DNA-mediated transformation involves the uptake of either linear or plasmid, naked DNA.**
  - b. A cell that is capable of being transformed is termed a competent cell and although a few genera of bacteria are naturally competent, most must be made competent using either a chemical treatment or electroporation.**
  - c. During transformation of a bacterial cell with a linear fragment of DNA, the fragment of donor DNA sometimes replaces a stretch of the recipient’s chromosome in two consecutive steps termed breakage and reunion.**
  - d. During transformation of a bacterial cell with a linear fragment of DNA, a single-stranded DNA molecule is transferred from the donor to the recipient cell via the F pilus.**
- \*It’s important to note that after linear DNA is taken up via transformation, it may be degraded. Thus, although transformation has occurred, recombination has not!**

\*If plasmid DNA is taken up by the cell during transformation, then the plasmid remains in the cytoplasm and replicates independently.

\*If linear DNA is taken up during transformation and it is NOT degraded:

1. **ENTRY** = A double-stranded piece of DNA adheres to the cell surface. One strand is degraded by nucleases and the other strand enters the cell. This mechanism varies amongst different genera.
2. **INTEGRATION** (nonreciprocal general recombination) = The ssDNA aligns with a region on the recipient cell’s chromosome to which it is highly homologous. (\*\*HIGHLY HOMOLOGOUS = VERY SIMILAR). The recipient DNA separates and pairs with the donor DNA. A nuclease cleaves the recipient cell’s DNA and releases the homologous section into the cytoplasm to be degraded by nucleases. This is called **BREAKAGE**. The donor DNA now replaces the recipient DNA = **REUNION**. This forms a region of **heteroduplex DNA** (one strand is donor DNA, the other is recipient DNA).

3. QUESTION FOR THOUGHT: After donor DNA has integrated into the recipient cell's chromosome, is stable transformation always accomplished? Why? **Answer - not always, sometimes the mismatch repair system catches errors and the sequence is unchanged. There's a 50/50 chance in terms of which strand will be repaired.**

**b. Transduction**

During **generalized transduction**, a bacteriophage (termed a defective phage) accidentally packages bacterial DNA into its capsid head rather than phage DNA. The phage still goes along to the next target cell but when it injects its DNA into the host cell, it only injects bacterial DNA. This donor (exogenote) DNA now has three possible fates: integration into the endogenote, degradation, or abortive transduction. How does this differ from **specialized transduction**?

**Practice: Which statement about generalized transduction is FALSE?**

**a. During generalized transduction, an error is made during the phage lysogenic life cycle. This error allows the phage to take a few specific bacterial genes, next to the point of integration, when it leaves the host chromosome.**

**b. During generalized transduction, any gene of the donor can be transferred to the recipient.**

**c. During generalized transduction, a phage is mistakenly packaged with bacterial DNA.**

**d. During generalized transduction, a defective phage is formed. This defective phage will effectively transfer genes from a donor cell to a recipient.**

**c. Conjugation =** The transfer of DNA from a donor to a recipient cell via cell-to-cell contact.

**Practice: Which one of the following is the most important means of plasmid transfer?**

**a. Transduction**

**b. Conjugation**

**c. Transformation**

**d. Translocation**

1. In order for a plasmid to be transferred from a donor cell to a recipient cell via conjugation, the plasmid must have a gene encoding for this transfer. Such plasmids are called **self-transmissible or conjugative** (e.g. **F (fertility)-plasmids** and **R (resistance)-plasmids**.)

2. Cells that are F<sup>+</sup> (male, donor or fertile cells) contain the F-plasmid. This plasmid encodes for the F pilus which serves as a bridge over which the F plasmid can be transferred from the donor cell to the F<sup>-</sup> (female or recipient cell). The transfer is always unidirectional and **only** the plasmid is transferred. (*The exact mechanism of plasmid transfer is still not entirely understood.*)

3. The steps of conjugation: The sex pilus of the donor cell binds to the

recipient cell and pulls the two cells together. This is often called **contact**. Next, the bottom strand of the F-plasmid is cleaved. This step is called **mobilization**. The rolling circle mechanism of replication is used during plasmid **transfer**. As the bottom strand of the original plasmid is transferred to the recipient cell, a complimentary strand is synthesized. This step is often called synthesis. Thus, after plasmid transfer, both the donor and recipient cell are F<sup>+</sup>.

**Practice: The F (fertility) plasmid**

**a. is transferred during a lateral gene transfer event called conjugation.**

**b. can be found only in male (donor) cells.**

**c. is self-transmissible and codes for the synthesis of a structure called the F pilus.**

**d. all of the above**

**e. only a and c**

4. R-plasmids contain genes allowing for resistance to certain antimicrobial substances and or heavy metals. These plasmids probably originated when transposons, carrying resistance genes, jumped into self-transmissible plasmids.

**Practice: In lab, we worked with a strain of *Staphylococcus aureus* that was resistant to penicillin. Which one of the following would probably be seen in this strain of *S. aureus*?**

**a. gas vesicles**

**b. an R plasmid**

**c. a lysogenic bacteriophage**

**d. a lytic bacteriophage**

**e. none of the above**

5. Chromosomal DNA transfer can occur when the F-plasmid in an F<sup>+</sup> cell integrates into the chromosome via homologous recombination. Cells in which this has occurred are termed **Hfr cells**. Chromosomal DNA can now be transferred via a mechanism very similar to plasmid transfer, however the two cells (donor and recipient) break contact before the entire chromosome can be transferred. The interesting part about this is that the F-plasmid itself is one of the last things on the chromosome so it is not transferred to the recipient cell, thus recipient cells remain F<sup>-</sup>.

**Practice: Hfr cells**

**a. are cells in which the F plasmid has become integrated into the chromosome.**

**b. can transfer part of their chromosome to a recipient cell. After this transfer the recipient cell will become F<sup>+</sup> and will also be capable of transferring its chromosome.**

**c. are always cells that have more than one R-plasmid.**

**d. have a higher propensity to take up plasmid DNA**

## V. Antimicrobial Therapy

Who was Paul Ehrlich?

### A. Terminology

**Practice: An antimicrobial drug**

- a. is a chemotherapeutic agent.**
- b. is any chemical used to treat microbial infection.**
- c. that has a high therapeutic index is selectively toxic**
- d. all of the above.**

\*An antibiotic is technically defined as an antimicrobial drug produced naturally by a microorganism. However, the term is used slightly loosely as many drugs are partially synthetic (e.g. ampicillin) or synthetic (e.g. sulfa drugs) and are still termed antibiotics.

**IMPORTANT: Be certain to understand therapeutic index, how to calculate it and what it means.**

### B. Mechanisms of action

1. Drugs that inhibit cell wall synthesis

The beta-lactam drugs:

**Practice: Beta-lactam drugs**

- a. are most commonly thought to inhibit the enzymes responsible for forming the tetrapeptide chains between strands of peptidoglycan.**
- b. contain a beta-lactam ring that is essential for activity.**
- c. include the penicillins and the cephalosporins.**
- d. are effective only when cells are actively growing.**
- e. are naturally more effective on Gram-positive cells.**
- f. generally have very few side effects.**
- g. all of the above**
- h. only a through c**



**Practice: The broad-spectrum penicillins**

- a. are effective against both Gram-positive and Gram-negative organisms.
- b. are isolated directly from *Penicillium chrysogenum* and undergo no further modification.
- c. include penicillin G and Penicillin V.
- d. include ampicillin and amoxicillin.
- e. a and d
- f. b and c

**Practice: The extended-spectrum penicillins**

- a. are partially synthetic.
- b. are the cephalosporins.
- c. include cephalexin.
- d. are effective against some tough Gram-negative bacteria like *Pseudomonas*.
- e. a and d
- f. b and c

Vancomycin

- a. Stops peptidoglycan synthesis by binding to the NAM side chains and precluding the linkage of the peptidoglycan layers.
- b. Often used when the beta-lactam antibiotics are ineffective but it must be administered intravenously.
- c. Can't cross the outer membrane of Gram-negatives and is thus ineffective against these organisms.

Bacitracin

**Practice: Bacitracin**

- a. inhibits cell wall synthesis by interfering with the transport of peptidoglycan precursors across the cytoplasmic membranes.
- b. is administered intravenously.
- c. is used only in topical ointments.
- d. a and b
- e. a and c

2. Drugs that inhibit protein synthesis

**Practice: Which one of the following is a drug that DOES NOT inhibit protein synthesis?**

- a. tetracycline
- b. streptomycin
- c. cephalexin
- d. erythromycin

\*Know the mechanisms of action of the antibiotics that inhibit protein synthesis; also be familiar with which bacteria they target (if discussed).

**Practice: The tetracyclines**

- a. bind to the 30S ribosomal subunit causing it to distort and malfunction.**
- b. include gentamicin and neomycin.**
- c. include doxycycline.**
- d. both a and b**

**Practice: Erythromycin is an aminoglycoside (T or F).**

3. We talked about only one class of drugs that **inhibit nucleic acid synthesis**. These are the fluoroquinolones and they inhibit the topoisomerases. Ciprofloxacin is an example.

4. Polymyxin B **perturbs cell membranes** and is used only topically.

C. Antiviral and antifungal drugs - Speculate as to why they are more difficult to develop?