

Par I. Multiple-choice (please write your answers in the designated area, only alphabets are accepted) 2 points each

Questions (1)-(2) belong to a series. Please select the answers from the following pool

- | | |
|---|-------------------------------|
| (a) P. Chambon and J. Abelson | (b) J. Steitz and C. Guthrie |
| (c) R.J. Roberts and P.A. Sharp | (d) T. Cech and R. Tjian |
| (e) electrophoretic mobility shift assay (EMSA) | (f) DNA footprinting |
| (g) R-looping | (h) Nearest neighbor analysis |
| (i) SDS-PAGE | |

In the years of late 1970s, two independent research groups led by (1) , respectively discovered the introns. Both groups demonstrated the presence of RNA splicing during RNA maturation, using the (2) experiment. In one of the experiments, the 5' ends of adenovirus fiber mRNA showed hybridization with the upstream region of viral DNA, indicating it is not encoded adjacent to the main bodies of the mRNAs.

- (3) Which of the following events would still result in a proliferation signal via the kinase cascade in the absence of ligand binding to its receptor tyrosine kinase:
- (a) A constitutively active MEK and a defective Ras.
 - (b) A constitutively active Raf and a defective MEK.
 - (c) A constitutively active Ras and a defective MEK
 - (d) A constitutively active Ras and a defective Raf.
- (4) What is the likely effect of increased cellular phosphatase activity on the ability of members of the TGF β superfamily to regulate cell patterning and cell proliferation?
- (a) Inhibition of TGF β superfamily effects.
 - (b) Promotion of TGF β superfamily effects.
 - (c) No effect.
 - (d) Immediate cell death.
- (5) Wild-type p53 acts as a tumor-suppressor gene in response to radiation by all of the following mechanisms **except**:
- (a) Arresting cells at the G1 checkpoint to repair DNA damage.
 - (b) Stimulating transcription of an inhibitor of cdks.
 - (c) Interacting with p21CIP.
 - (d) Activating apoptosis.

- (6) One maternal copy of a mutated *bicoid* gene containing a deletion of the 3' untranslated end would result in an embryo with *hunchback* transcribed
- (a) At the anterior end only.
 - (b) Throughout the embryo.
 - (c) At the posterior end only.
 - (d) Not at all.
- (7) Please choose the best answer. Retroviruses are capable of causing cancer because they
- (a) Cause *c-oncs* to mutate to *v-oncs*.
 - (b) Contain point mutations in *pol*.
 - (c) Contain mutant versions of cellular genes that normally regulate cell growth.
 - (d) Pick up a *c-onc* from the genome.
- (8) Please chose the correct statement(s). Eukaryotic mRNAs
- (a) are found to have long runs of A at their 3' ends.
 - (b) are found to have their 5' ends blocked by the addition of 7-methyl-Gp caps.
 - (c) are transcribed by the enzyme DNA polymerase II.
 - (d) must exit from the nucleus before it can be translated.
- (9) Please chose the correct statement(s).
- (a) DNA polymerases catalyze the formation of DNA only in the presence of preexisting DNA templates.
 - (b) Supercoiled DNA adopts a more compact configuration than its "relaxed" equivalents.
 - (c) Nonsense suppressor tRNAs cause misreading of the genetic code.
 - (d) Promoters are the start signals for RNA synthesis.
 - (e) Tryptophan starvation decreases expression of the *trp* operon.
- (10) The immune systems of vertebrates can produce millions of different antibodies to react with virtually any foreign substance. Which of the following mechanisms are responsible for the generation of such enormous immune diversity?
- (a) somatic mutations creating a slightly different gene.
 - (b) clonal selection.
 - (c) combination of light chains and heavy chains into an antibody molecule.
 - (d) assembling genes for antibody light and heavy chains from heterogeneous pools of parts (the joining of V-(D)-J segments).
 - (e) imprecise joining of V-(D)-J segments.

(11) Which of the following operons are positively regulated by catabolite activator protein?

- (a) lactose operon
- (b) histidine operon
- (c) tryptophan operon
- (d) arabinose regulon
- (e) maltose operon

(12) What mechanism does λ phage use to express its late genes?

- (a) by positive control
- (b) by negative control
- (c) by induction
- (d) by repression
- (e) by antitermination

Part II. Fill in blanks (Please write down your answers in the designated area) 2 points each

A relaxed circular DNA molecule can be twisted into a negatively supercoiled molecule by the action of (1).

A point mutation that converts a codon to a stop codon is called a (2).

Escherichia coli cells normally synthesize the enzyme β -galactosidase at high rates only when (3) is present.

The key to the beadlike organization of eukaryotic chromatin is its (4). They come together to form (5) units.

RNA polymerase III transcription is regulated by (6).

Cyclin B are polyubiquitinated and degraded during (7). (hint: phase or stage of cell cycle)

Misexpression of (8) genes during embryogenesis causes homeotic transformation, i. e., the development of body parts in abnormal positions.

(9) is an adaptor protein that binds to specific phosphotyrosines in activated receptor tyrosine kinases and a guanine-nucleotide exchange factor.

The effector molecules in the apoptotic pathway are a family of enzymes called (10).

The (11) is a specialized attachment site of microtubules at the chromosome centromere.

(12) is the initiating amino acid in prokaryotic translation.

(13) is an RNA-dependent DNA polymerase that is commonly found in the retroviruses.

(14) is a stretch of about 20 amino acids, usually at the amino terminus of a polypeptide, that helps to anchor the nascent polypeptide and its ribosome in the endoplasmic reticulum. Polypeptides with this stretch of amino acids are destined for packaging in the Golgi apparatus and are usually exported from the cell.

(15) is a riboprotein that can extend the ends of eucaryotic linear chromosomes after DNA replication.

(16) is a prokaryotic protein which, along with single strand binding protein, coats a single-stranded DNA tail and allows it to invade a DNA duplex to search for a region of homology in homologous recombination. Also functions as a co-protease during the SOS response.

Proofreading is the process a cell uses to check the accuracy of DNA replication as it occurs and to replace a mis-paired base with the right one. (17) is the enzymatic activity of DNA polymerases required to perform the proofreading.

(18) is a DNA element that strongly stimulates transcription of a gene or genes. These elements are usually found upstream of the genes they influence, but they can also function if inverted or moved hundreds or even thousands of base pairs away.

(19) fragments are small DNA fragments, 1000-2000 bases long, created by discontinuous synthesis of the lagging strand during DNA replication.

Assuming wobble can occur, what two codons (20, 21) could be recognized by the anticodon 5'-GAG-3'. Write the codon in the 5'-3' direction.

Define terms (4 points each)

- (1) C-value paradox
- (2) $Cot_{1/2}$ value in the DNA renaturation
- (3) Positional cloning
- (4) Single-stranded conformational polymorphism
- (5) Hybrid dysgenesis

Part VI. Short essay

- (1) What are the minimum features required for the existence as an eucaryotic chromosome? (5 points)
- (2) The size of the *E. coli* genome is 4×10^6 bp. What is the possible frequency of cuts when restriction enzyme *EcoRI* is applied to the *E. coli* DNA? (4 points)
- (3) What will happen in mutant cells that cannot phosphorylate the tumor-suppressor Rb? (5 points)