

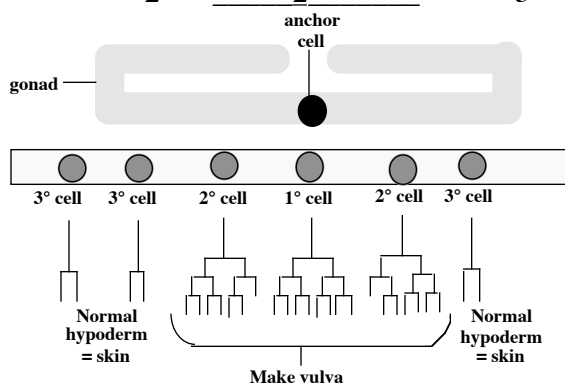
BIOLOGY 52 - - CELL AND DEVELOPMENTAL BIOLOGY - - FALL 2002  
Fourth Examination - - December 2002

**Answer each question, noting carefully the instructions for each.**  
**Repeat- Please read the instructions for each question before answering!!!**  
**Be specific in each answer, and print name on top of each page! (I mean it!)**

1. (2 Points) We discussed a number of “transcription factors”, e.g., Pax-6. They play a critical role in embryonic development. What is transcription?

2. (10 points) The diagram shows the cell fates chosen by different cells of the vulval equivalence group in a wild-type worm. How many 1° cells, how many 2° cells, and how many 3° cells will be made in each of the cases listed below? Hint: in wild-type (total =six) the answer is

1° 1                      2° 2                      3° 3



In a mutant in which the anchor cell is ablated but the gonad remains (total =six)

1° \_\_\_\_\_                      2° \_\_\_\_\_                      3° \_\_\_\_\_

In a worm homozygous mutant for the ras GTPase which is downstream of and activated by a signal from the receptor for the anchor cell signal (total=six)

1° \_\_\_\_\_                      2° \_\_\_\_\_                      3° \_\_\_\_\_

In an animal in which the outside three vulval precursor cells were killed with a laser beam (total =3)

1° \_\_\_\_\_                      2° \_\_\_\_\_                      3° \_\_\_\_\_

In an animal in which the central three vulval precursor cells were killed with a laser beam (total =3)

1° \_\_\_\_\_                      2° \_\_\_\_\_                      3° \_\_\_\_\_

In an animal that expresses in all of its cells a mutant form of the receptor for the anchor cell signal, which is always active, even in the absence of ligand, and which is also homozygous mutant for *lin-12* (i.e., completely lacks functional lin-12 protein) (total =6)

1° \_\_\_\_\_                      2° \_\_\_\_\_                      3° \_\_\_\_\_

3. (3 points) You are a scientist studying the biology behind “cloning”, i.e., the production of genetically identical individuals. You are carrying out your work on the frog, and are trying to select a nuclear donor for your transplantation experiment. Which of the following cell types would give you the **highest** likelihood of success (Choose ONE)? \_\_\_\_\_

- A. A skin cell
- B. A uterine cell.
- C. A follicle cell.
- D. A neurula stage gut cell.
- E. A early blastocyst cell.
- F. A neuron from the cerebellum

Why? \_\_\_\_\_

4. (2 points-Put letter(s) for ALL correct answers in each blank—each may have one or more than one answer) You begin a tissue culture dish filled with

skin cells. Which of the following genes is it likely these cells are transcribing? \_\_\_\_\_  
 You now transfect these cells such that all now express myoD. Which of the following mRNAs is it

likely these cells are transcribing? \_\_\_\_\_

- |                           |  |
|---------------------------|--|
| A. Muscle-specific myosin | D. Neurotransmitter receptor.              |
| B. Skin-specific keratin. | E. Bone extracellular matrix protein bone. |
| C. RNA polymerase         | F. Tubulin                                 |

5. (4 points) We discussed several global methods of regulating gene expression. Treatment with azacytidine affected one of them. What effect does treatment with azacytidine have? \_\_\_\_\_

\_\_\_\_\_ Another mechanism of global gene regulation involved the posttranslational modification of a particular class of PROTEINS associated with

DNA—which specific type of proteins was this? \_\_\_\_\_

6. (5 points; choose the best answer for each blank) In the normal embryo, Engrailed protein is expressed from the blastoderm stage until adulthood in only the most posterior cells of each segment, and acts as a master regulator of posterior cell fates.

- A) Posterior cells
- B) Anterior cells
- C) All cells
- D) No cells

Which cells within each segment express Engrailed protein:

at the blastoderm stage in a *wingless* mutant embryo? \_\_\_\_\_

at the end of embryogenesis in a *wingless* mutant embryo? \_\_\_\_\_

at the blastoderm stage in an embryo making a non-functional Engrailed protein? \_\_\_\_\_

at the end of embryogenesis in an embryo making a non-functional Engrailed protein? \_\_\_\_\_

at the end of embryogenesis in an embryo mutant for the *Polycomb* gene? \_\_\_\_\_

7. (Choose the best answer-8 points) **Where** within the cell would the following proteins be found?

- |                                       |   |
|---------------------------------------|---|
| A. Nucleus                            | B. Transmembrane protein in the plasma membrane |
| C. Lysosome.                          | D. Anchored in cytoplasm                        |
| E. Secreted and thus outside the cell | F. In mitochondria                              |

Engrailed \_\_\_\_\_

Bicoid \_\_\_\_\_

MyoD \_\_\_\_\_

Ultrabithorax \_\_\_\_\_

Wingless \_\_\_\_\_

Kruppel \_\_\_\_\_

Maintenance methylase \_\_\_\_\_

Notch \_\_\_\_\_

Delta \_\_\_\_\_

lin-12 \_\_\_\_\_

The receptor for the anchor cell signal \_\_\_\_\_

Wnt-1 \_\_\_\_\_

PDGF Receptor \_\_\_\_\_

Steel \_\_\_\_\_

Rb \_\_\_\_\_

PDGF \_\_\_\_\_

8. (1 point) *C. elegans lin-12* encodes a relative of which fruit fly protein? \_\_\_\_\_

9. (3 points) If a person suffers from Xeroderma pigmentosum, they are excessively sensitive to sunlight. What biochemical process is impaired in these individuals? \_\_\_\_\_

10. (4 points) Use the choices below to fill in the BEST answer in each blank:

- a. Secreted or membrane-bound cell-cell signal.
- b. Transmembrane receptor.
- c. G protein.
- d. Transcription factor.
- e. Protein kinase
- f. Transmembrane cell-adhesion protein
- g. Cytoskeletal protein

Pax-3 protein acts as a _____	AbdB protein acts as a _____
Mouse engrailed protein acts as a _____	Src protein acts as a _____
E-cadherin protein acts as a _____	ras protein acts as a _____
Steel protein acts as a _____	Rb protein acts as a _____
MyoD protein acts as a _____	Abl protein acts as a _____
Bicoid protein acts as a _____	Actin protein acts as a _____

11. (4 points) Match the term with the BEST definition (one choice will NOT be used)

- A. Special chromatin protein that helps turn off *engrailed* transcription.
- B. Fruit fly homolog of Wnt-1.
- C. Mutated in *Splotch* mutant mice.
- D. Ion channel that transports chloride ions.
- E. One of the gap gene transcription factors.
- F. Methylates hemimethylated DNA.
- G. Main protein component of chromatin.
- H. Acts as a sensor for DNA damage and can induce programmed cell death.
- I. Regulatory G-protein mutated in many types of human cancer.

Knirps protein _____	p53 _____
Cystic fibrosis protein _____	Histone _____
Pax-3 _____	Maintenance methylase _____
Wingless _____	Polycomb _____

12. The following 5 true-or-false questions are worth 8 points in total. Mark each as T or F and for any that is/are false, indicate briefly why in the space below.

- a. T F The protein encoded by the homeotic gene *abdominal A* is a G-protein.
- b. T F *Ultrabithorax* and *Abdominal B* encode related proteins.
- c. T F After fertilization, fruit fly embryos go through a stage with many nuclei in one cell.
- d. T F A patch of cells mutant for *Notch* can be rescued by wild-type neighbors.
- e. T F In an embryo mutant for *Delta* all ventral ectodermal cells take on the epidermal fate.

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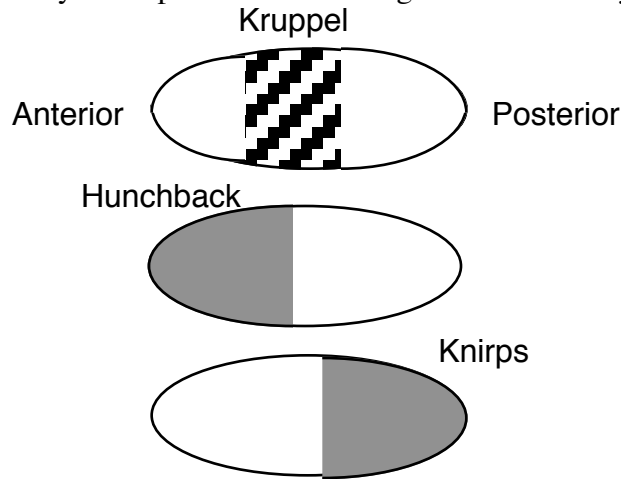
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13. (7 points-Fill in or circle the correct answers). We discussed the mechanism of action of one critical determinant of the anterior posterior pattern, the protein Bicoid. It is expressed in a gradient with the highest levels

of expression at the \_\_\_\_\_ end of the embryo. It then regulates the

(CIRCLE ONE) transcription / translation of a set of genes whose expression patterns are diagrammed below.

They are expressed in broad regions of the embryo and are known as the \_\_\_\_\_ genes.



Based on the expression patterns at left, which gene is turned on only by HIGH levels of Bicoid

(Choose one) \_\_\_\_\_

Which gene is turned off by Bicoid \_\_\_\_\_

(Choose the best answer from the list below) In an embryo mutant for *bicoid*, where would *knirps* be expressed? \_\_\_\_\_

In an embryo genetically engineered to express high levels of Bicoid everywhere, where would *knirps* be expressed? \_\_\_\_\_

- a. Nuclei at posterior end.
- b. Nuclei at anterior end
- c. All nuclei
- d. Nowhere

14. (2 points—all or none) From what you learned in recitation, order the following animals from **shortest to longest life-cycle**.

- A. The blue whale
- B. The mouse
- C. *Drosophila melanogaster*
- D. *C. elegans*

Shortest \_\_\_\_\_ < \_\_\_\_\_ < \_\_\_\_\_ < \_\_\_\_\_ Longest

(1 point) What does *C. elegans* eat in the lab? \_\_\_\_\_

15. (2 points—all or none) Order the following events in human development, from earliest to latest:

- A. Implantation in the uterus
- B. Gastrulation
- C. Fertilization
- D. Compaction
- E. Neurulation
- F. Formation of blastocyst

Earliest \_\_\_\_\_ < \_\_\_\_\_ < \_\_\_\_\_ < \_\_\_\_\_ < \_\_\_\_\_ < \_\_\_\_\_ Latest

16. (3 points) p53 protein is often called the "guardian of the genome". It carries out this role by acting as part of a checkpoint in the cell cycle. Choose from the list **the most likely immediate** response of the following cells if the cell is exposed to mutagenic doses of X-rays:

Normal (i.e., wild-type) cell \_\_\_\_\_ Cell which lacks p53 protein \_\_\_\_\_  
 Cell heterozygous mutant for *p53* \_\_\_\_\_

- A. Metastasize to a distant place in the body.
- C. Lose contact inhibition of growth.
- B. Halt the cell cycle until the DNA is repaired.
- D. Continue the cell cycle without halt.

17. (2 points: Circle one) The cell biological function of the normal Retinoblastoma protein is to:

- A. Repair damaged DNA.
- C. Phosphorylate integrins, promoting cell motility.
- B. Turn on genes required for cell proliferation.
- D. Turn off genes required for cell proliferation.

18. (9 points) You want to "knock-out" the mouse BRCA1 gene (mutations in this gene in people cause familial predisposition to breast cancer).

You start with a cell line called ES cells. From what source was this cell line originally derived?

\_\_\_\_\_ You add to these cells cloned DNA carrying the BRCA1 gene. You modified this DNA by adding a second gene replacing the coding sequences of the BRCA1 gene. What is the **biochemical**

**function** of the protein encoded by this second gene? \_\_\_\_\_

Most cells do not incorporate the second gene into their own DNA-- only a very small percentage do so. How do you select cells that have incorporated the DNA? \_\_\_\_\_

(Circle one) At this point the cell line is homozygous / heterozygous mutant.

You inject these cells into a blastocyst stage embryo. The resulting mouse derived from this embryo is chimeric. Which of the following tissues may be derived from the altered ES cells (Circle all correct answers)

Muscle

Blood

Skin

Liver

Sperm/eggs

Brain

19. (4 points) We discussed the roles of Steel and White-spotting in the survival of various stem cell populations. Among them were bone marrow stem cells. We also talked about how one could make chimeric animals to test which encodes the signal (or is involved in its production), and which encodes the receptor (or the machinery to transduce the signal). Normally, stem cells live inside the bone marrow, where they are surrounded by stromal cells. A survival signal from the stromal cells is required for survival and proliferation of the bone marrow stem cells. If one transplants Steel mutant bone marrow stem cells into a wild-type host, the mutant bone marrow is "rescued," and thus survives

and proliferates. This is because Steel encodes the (CIRCLE ONE) Ligand / receptor.

For each of the following transplants, describe the fate of the bone marrow stem cells (i.e., in each choose SURVIVES or DIES).

Bone marrow stem cells from a White spotting mutant transplanted into a wild-type host?

SURVIVES / DIES

Bone marrow stem cells from a wild-type mouse transplanted into a White spotting mutant host?

SURVIVES / DIES

Bone marrow stem cells from a wild-type mouse transplanted into a Steel mutant host?

SURVIVES / DIES

20. (2 points- fill in the blanks) The NF1 gene is a tumor suppressor, analogous to Rb. The normal function of NF1 protein is to suppress cell proliferation, and its genetics are similar to those of Rb, with NF1 playing a role in neurofibroma development (tumors of the nervous system) similar to that Rb plays in retinoblastoma. Choose the correct genotype from among those listed:

A. + / +

B. NF1<sup>mutant</sup> / +

C. NF1<sup>mutant</sup> / NF1<sup>mutant</sup>

A skin cell from a normal individual? \_\_\_\_\_

A cell in a sporadic nervous system tumor that arose in a normal individual? \_\_\_\_\_

A skin cell from an individual with a familial predisposition to neurofibromas? \_\_\_\_\_

A nervous system tumor cell from an individual with a familial predisposition to neurofibroma? \_\_\_\_\_

21. (3 points) Advanced tumors become most difficult to treat when they have acquired the ability to metastasize, in other words to leave the original tumor and travel to distant parts of the body and form secondary tumors.

To do so, tumors turn **OFF** expression of which family of transmembrane proteins? \_\_\_\_\_

By what route do they travel to distant sites, and what normal type of cell also travels by this same route? \_\_\_\_\_

22. The following four true-or-false questions are worth 5 points in total. Mark each as T or F and for any that is/are false, indicate briefly why in the space below.

- a. T F Cancer cells can evade normal programmed cell death.
- b. T F A single mutation is not enough to cause cancer.
- c. T F Retroviral activation of mouse *engrailed* can contribute to mouse breast cancer.
- d. T F Mutations caused by smoking accelerate the development of cancer.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

23. (7 points) Skin cells normally proliferate at a slow rate in the body, replacing those lost due to normal attrition, and remain firmly attached to the basal lamina. When the skin is wounded, what happens to the cell migration rate of skin cells?

(Choose ONE)      It increases      /      It remains the same      /      It decreases.

In response to a wound, skin cells loosen their hold on the basal lamina and migrate into the wound site. This is stimulated by a signaling molecule called PDGF made by a particular type of blood cell. This ligand binds to PDGF receptors on skin cells—the cytoplasmic domain of the PDGF receptor has which

**enzymatic activity?** \_\_\_\_\_

Through a cascade of signal transduction events, a downstream protein called Src is activated. Src is normally inactive except when the cell sees the PDGF. Imagine two different types of mutation in Src. Mutation 1 (Src-ACTIVATED) renders it constitutively active. Mutation 2 (Src-INACTIVE) kills the normal function of the protein. Normal Src is designated “+”. Would skin cells of the following genotypes to alter their adhesion to the ECM and migrate, in the absence or presence of PDGF? In each blank, fill in either STAYS PUT or MIGRATES:

	Absence of PDGF	Presence of PDGF
+ / +	_____	_____
Src-INACTIVE / Src-INACTIVE	_____	_____
Src-INACTIVE / +	_____	_____
Src-ACTIVATED / +	_____	_____
Src-ACTIVATED / Src-ACTIVATED	_____	_____

I certify that I have performed my work on this examination in full conformity with the provisions of the Honor Code.

Signature \_\_\_\_\_