Honors Bio Ch 8 PPT Notes

**Why do cells divide?**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

asexual reproduction

one-celled organisms

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

from fertilized egg to
multi-celled organism

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

replace cells that die from normal wear & tear or from injury

**Making new cells**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

chromosomes

DNA

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

centrioles

in animals

microtubule spindle fibers

**Cytoskeleton**

Function

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

maintains shape, provides anchorage

protein fibers

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

cell locomotion

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Organizes cell activities

**Centrioles**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

in animal cells, pair of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

organize microtubules

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

guide chromosomes in mitosis

**Getting the right stuff**

What is passed on to daughter cells?

exact copy of genetic material = \_\_\_\_\_\_\_

organelles, cytoplasm, cell membrane, enzymes

**Interphase**

Most of a cell’s life cycle (~95%)

cell doing its “everyday job”

synthesize proteins/enzymes, metabolism, etc.

prepares for duplication if triggered

**Cell cycle**

Cell has a “life cycle”

**Interphase**

Divided into 3 phases:

­­\_\_\_\_\_\_\_= 1st \_\_\_ap (\_\_\_\_\_rowth)

Non-dividing life

\_\_\_\_\_ = DNA \_\_\_ynthesis

copies chromosomes

\_\_\_\_\_ = 2nd \_\_\_ap (\_\_\_rowth)

prepares for division

cell grows (more)

produces organelles,
proteins, membranes

**Interphase**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_



Prepares for mitosis

replicates chromosome

DNA & proteins

produces proteins & organelles

**S phase: Copying / Replicating DNA**

Synthesis phase of Interphase

dividing cell replicates DNA

must separate DNA copies correctly to 2 daughter cells

human cell duplicates ~3 meters DNA

each daughter cell gets complete
identical copy

error rate = ~1 per 100 million bases

3 billion base pairs in mammalian \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

~30 errors per cell cycle

mutations (\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)

**Organizing DNA**

DNA is organized in
chromosomes

double helix DNA molecule

wrapped around \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

like thread on spools

DNA-protein complex =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

organized into long thin fiber

condensed further during mitosis

**Copying DNA & packaging it…**

After DNA duplication, chromatin \_\_\_\_

coiling & folding to make a smaller package

**Mitotic Chromosome**

Duplicated chromosome

2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

narrow at \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

contain identical
copies of original DNA

**Mitosis**

Dividing cell’s DNA between
2 daughter nuclei

“dance of the chromosomes”

4 phases

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Prophase**



Chromatin condenses

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Centrioles move to opposite poles of cell

animal cells only

Protein fibers cross cell to form mitotic spindle

microtubules

coordinate movement of chromosomes

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Transition to Metaphase**

Prometaphase

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Kinetochores

connect centromeres to centrioles

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Metaphase**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

metaphase plate

meta = middle

spindle fibers coordinate movement

ensure chromosomes separate properly

each new nucleus receives 1 copy of each chromosome

**Anaphase**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_at centromere

move to opposite poles

pulled by motor proteins “walking”along microtubules

Poles move farther apart

polar microtubules lengthen

**Separation of chromatids**

In anaphase, proteins holding together sister chromatids are inactivated

separate to become individual chromosomes

**Chromosome movement**

Kinetochores use motor proteins that “walk” chromosome along attached microtubule

microtubule shortens by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Telophase**

Chromosomes arrive at opposite poles

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Spindle fibers disperse

Cytokinesis begins

cell division

**Cytokinesis**

Animals

constriction belt of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_microfilaments around equator of cell

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ forms



splits cell in two

like tightening a draw string

**Cytokinesis in Plants**

Plants

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ forms

Vesicles (from golgi) line up at equator

vesicles fuse to form 2 cell membranes

new cell wall laid down between membranes

new cell wall fuses with existing cell wall

**Evolution of mitosis**

Mitosis in eukaryotes
likely evolved from \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in bacteria

single circular chromosome

no membrane-bound organelles

Chapter 8 Part 2 Regulation of Cell cycle

**Coordination of cell division**

A multicellular organism needs to coordinate cell division across different tissues & organs

critical for normal growth,
development & maintenance

Timing, Rates and Orchestration all need to be controlled

**Frequency of cell division**

Frequency of cell division varies by cell type

embryo

cell cycle < 20 minute

skin cells

divide frequently throughout life

12-24 hour cycle

liver cells

retain ability to divide, keep it in reserve

divide once every year or two

mature nerve cells & muscle cells

do not divide at all after maturity (?)

permanently in G0

**Overview of Cell Cycle Control**

Two irreversible points in cell cycle

replication of genetic material

separation of sister chromatids

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

process is assessed & possibly halted

**Checkpoint control system**

Checkpoints

cell cycle controlled by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ chemical signals at critical points

signals indicate if key cellular processes have been completed correctly

**Checkpoint control system**



3 major checkpoints:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

can DNA synthesis begin?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

has DNA synthesis been completed correctly?

commitment to mitosis

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

are all chromosomes attached to spindle?

can sister chromatids separate correctly?

**G1/S checkpoint**

G1/S checkpoint is most critical

primary decision point: “\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_”

if cell receives “\_\_\_\_\_\_\_\_\_\_\_\_” signal, it divides

internal signals: cell growth (size), cell nutrition

external signals: “growth factors”

if cell does \_\_\_\_\_\_\_\_\_\_\_\_\_\_receive
signal, it exits cycle &
switches to \_\_\_\_\_\_\_\_\_\_\_\_\_\_ phase

non-dividing, working state

**G0 phase**

G0 phase

non-dividing, differentiated state

most human cells in G0 phase

liver cells

in G0, but can be “called back” to cell cycle by external cues

nerve & muscle cells

highly specialized

arrested in G0 & can never divide

**Activation of cell division**

How do cells know when to divide?

cell communication \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

chemical signals in cytoplasm give cue

signals usually mean \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

activators

inhibitors

**“Go-ahead” signals**

Protein signals that promote cell growth & division

internal signals

“\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_”

external signals

“\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_”

Primary mechanism of control

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ enzymes

either activates or inactivates cell signals



**Cell cycle signals**

Cell cycle controls

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

regulatory proteins

levels cycle in the cell

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

cyclin-dependent kinases

phosphorylates cellular proteins

activates or inactivates proteins

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

triggers passage through different stages of cell cycle

**Cyclin & Cyclin-dependent kinases**

CDKs & cyclin drive cell from one phase to next in cell cycle

proper regulation of cell cycle is so key to life that the genes for these regulatory proteins have \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_through evolution

the genes are basically the same in yeast, insects, plants & animals (including humans)

**External signals**

Growth factors

coordination between cells

Proteins released by body cells that stimulate other cells to divide

­­­­­\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

crowded cells stop dividing

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

to divide cells must be attached to a substrate

**Example of a Growth Factor**

Platelet Derived Growth Factor (PDGF)

made by platelets in blood clots

binding of PDGF to cell receptors stimulates cell division in connective tissue

heal wounds

**Growth Factors and Cancer**

Growth factors can create cancers

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

normally activates cell division

growth factor genes. Become “oncogenes” (cancer-causing) when mutated

if switched “\_\_\_\_\_” can cause cancer

example: RAS (activates cyclins)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

normally inhibits cell division

if switched “\_\_\_\_\_\_\_” can cause cancer

example: p53

**Cancer & Cell Growth**

Cancer is essentially a failure
of cell division control

unrestrained, uncontrolled cell growth

What control is lost?

lose checkpoint \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

gene \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ plays a key role in G1/S restriction point

p53 protein halts cell division if it detects damaged DNA

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cancers have to shut down p53 activity

**Development of Cancer**

Cancer develops only after a cell experiences ~6 key mutations (“hits”)

unlimited growth

turn \_\_\_\_\_\_\_\_\_\_\_ growth promoter genes

ignore checkpoints

turn \_\_\_\_\_\_\_ tumor suppressor genes (p53)

escape apoptosis

turn \_\_\_\_\_\_ suicide genes

immortality = unlimited divisions

turn\_\_\_\_\_ chromosome maintenance genes

promotes blood vessel growth

turn\_\_\_\_\_\_ blood vessel growth genes

overcome anchor & density dependence

turn \_\_\_\_\_ touch-sensor gene

**What causes these “hits”?**

Mutations in cells can be triggered by

UV radiation -- chemical exposure-- radiation exposure --- heat --- cigarette smoke --- pollution --- age --- genetics

**Tumors**

Mass of abnormal cells

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

abnormal cells remain at original site as a lump

p53 has halted cell divisions

most do not cause serious problems &
can be removed by surgery

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

cells leave original site

lose attachment to nearby cells

carried by blood & lymph system to other tissues. start more tumors = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

impair functions of organs throughout body

**Traditional treatments for cancers**

Treatments target rapidly dividing cells

high-energy radiation: kills rapidly dividing cells

chemotherapy

stop DNA replication

stop mitosis & cytokinesis

stop blood vessel growth

**Cell division / Asexual reproduction**

Mitosis

produce cells with same information

identical daughter cells

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

clones

same amount of DNA

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Asexual reproduction**

Single-celled eukaryotes

yeast (fungi)

Protists

Paramecium

Amoeba

Simple multicellular eukaryotes

Hydra

**How about the rest of us?**

What if a complex multicellular organism (like us) wants to reproduce?

joining of egg + sperm

Do we make egg & sperm by mitosis?

**Homologous chromosomes**

Paired chromosomes

both chromosomes of a pair carry “matching” genes

control same inherited characters

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**How do we make sperm & eggs?**

Must reduce 46 chromosomes  23

must reduce the number of chromosomes by\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Meiosis: production of gametes**

Meiosis

chromosome number must be reduced

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

humans: 46  23

makes \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ restores chromosome number

haploid  diploid

n  2n

**Meiosis**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

special cell division for sexual reproduction

reduce 2n  1n

diploid  haploid

“two”  “half”

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

sperm, eggs

**Preparing for meiosis**

1st step of meiosis

Duplication of DNA

Why bother?

meiosis evolved after mitosis

convenient to use
“machinery” of mitosis

DNA replicated in
S phase of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
(just like in mitosis)

**Meiosis 1**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of meiosis separates \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Meiosis 2**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of meiosis separates \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Trading pieces of DNA**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

during \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, sister chromatids intertwine

homologous pairs swap
pieces of chromosome

DNA breaks & re-attaches

**Crossing over**

3 steps

cross over

breakage of DNA

re-fusing of DNA

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Mitosis vs. Meiosis**

Mitosis

1 division

daughter cells genetically identical to parent cell

produces 2 cells

2n  2n

produces cells for growth & repair

no crossing over

Meiosis

2 divisions

daughter cells genetically different from parent

produces 4 cells

2n  1n

produces gametes

crossing over

**The value of sexual reproduction**

Sexual reproduction introduces genetic variation

genetic recombination

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of chromosomes

random alignment of homologous chromosomes in Metaphase 1

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

mixing of alleles across homologous chromosomes

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

which sperm fertilizes which egg?

Driving evolution

providing variation for natural selection

**Variation from genetic recombination**

Independent assortment of chromosomes

meiosis introduces genetic variation

gametes of offspring do not have same combination of genes as gametes from parents

random assortment in humans produces
223 (8,388,608) different combinations in gametes

**Variation from crossing over**

Crossing over creates completely new combinations of traits on each chromosome

creates an infinite variety in gametes

**Variation from random fertilization**

Sperm + Egg = ?

any 2 parents will produce a zygote with over 70 trillion (223 x 223) possible diploid combinations (not even counting crossing over!!!!!!!!!)



**Sperm production**

Spermatogenesis

continuous & prolific process

each ejaculation = 100-600 million sperm

**Egg production**

Oogenesis

eggs in ovaries halted before Anaphase 1

Meiosis 1 completed during maturation

Meiosis 2 completed after fertilization

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_