

Psych 56L/ Ling 51:  
Acquisition of Language

Lecture 4

Biological Bases of Language Acquisition II

Announcements

Review questions for biological bases of languages available

Be working on HW1 (due 10/21/14) – remember that collaboration is highly encouraged

The critical period hypothesis



Critical & sensitive periods

“critical period for language” = biologically determined period during which language acquisition **must** occur in order for language to be learned fully and correctly

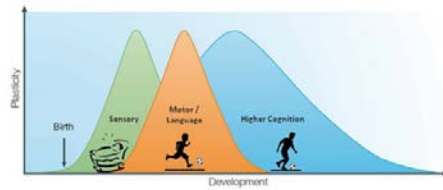
Other biologically determined deadlines:

- **imprinting**: chicks & ducklings follow first thing they see forever (it’s likely their mommy)
- **visual cells in humans**: if cells for both eyes don’t receive visual input during the first year or so of life, they lose the ability to respond to visual input

## Critical & sensitive periods

“sensitive period”: biologically determined period during which learning must occur for development to happen correctly, but development can still occur partially after this period

Fig 1: Windows of plasticity in brain development



Adapted from Hensch, T.K. (2005). Critical period plasticity in local cortical circuits. *Nature Reviews Neuroscience*, 8(11), 877-888.

## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?



## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

(1) **Ideal experiment: deprive children of all linguistic input** during the purported critical/sensitive period and see how language development occurs.



Problem: ideal experiment isn't so ideal ethically or logistically

## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Some historical cases that have unintentionally provided lack of linguistic input to children:

“wild children”: like Victor of Aveyron

Problem: unclear lack of language is solely due to lack of linguistic input (may be other factors)



## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

One success story for lack of linguistic input with a young child: [Isabelle](#)

1930s: 6-year-old Isabelle discovered hidden away in a dark room with a deaf-mute mother as her only contact.

She was taught to speak and by age 8, appeared to be normal.

Potential implication: Isabelle discovered before critical period was over.

## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

A more thorough study: [Genie](#)



## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

A more thorough study: [Genie](#)

1970s: 13-year-old Genie brought by her mother to social services after escaping mentally ill father; until mother's escape, had no language input (and very horrific living conditions)

By age 17, she had a five-year-old's vocabulary, and could express meanings by combining words together.

## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

A more thorough study: [Genie](#)

However...syntactic skills lagged far behind - deficient in both production and comprehension.

"Mama wash hair in sink."

"Like go ride yellow school bus."

"At school scratch face."

"Father take piece wood. Hit. Cry."

"I want Curtiss play piano."

"Applesauce buy store"

"Man motorcycle have."

"Father hit Genie cry long time ago."

Dichotic listening tasks showed language was a [right-hemisphere activity](#) for her (while it's a left-hemisphere activity for most adults).

## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

A more thorough study: [Genie](#)

**Potential Implication:** Genie discovered after critical period was over.

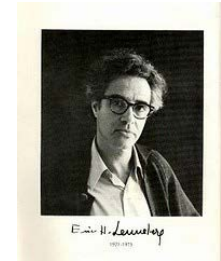
However, Genie may have had other cognitive disabilities...

## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Lenneberg (1967):

“the only safe conclusions to be drawn from the multitude of reports is life in dark closets, wolves’ dens, forests, or sadistic parents’ backyards is not conducive to good health or normal development”



## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Another study: [Chelsea](#) (Curtiss 1988)

**Family background:** A partially deaf woman incorrectly diagnosed as “retarded”. From a loving home.

**Discovered** at age 31, and fitted with hearing aids

**Outcome:** Learned a large vocabulary, but syntax and morphology worse than Genie.

## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Another study: [Chelsea](#) (Curtiss 1988)

Sample speech from Chelsea:

- (1) The small a the hat
- (2) Orange Tim car in
- (3) I Wanda be drive come
- (4) Breakfast eating girl
- (5) They are is car in the Tim

## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

(2) **Late acquisition of sign language (ASL): deaf-of-hearing children** whose parents don't know sign language. Children are eventually exposed to sign language when they encounter other deaf children.

Good: individuals have normal early childhood experience, except for lack of language input

## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

If a critical or sensitive period is true, **children who learn earlier should be better than children who learned later** - this is what Newport (1990) found. Children who were 4 to 6 years old when first exposed to ASL were far superior in their sign language ability when compared to children who were exposed after age 12.



## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Also important: not just about how long sign language speakers had known the language. **Speakers who had been signing for more than 30 years showed this same difference:** those exposed younger were far superior in their language skills to those exposed when they were older.



## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

(3) **Look at second language learning.**

Why? Children who learn a second language when they are young often become indistinguishable from their native-born peers. In contrast, people who are older have very different outcomes.



## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Testing age differences in second language acquisition:

- Oyama (1976): testing Italian immigrants learning English  
**Age of arrival** was better predictor of **accent** than how many years the immigrant had been speaking English
- Oyama (1978): **Age of arrival** was better predictor of **comprehension** than number of years speaking the language (not just about motor skill learning ability)

## Critical & sensitive periods

How do we test for a critical/sensitive period for language acquisition?

Testing age differences in second language acquisition:

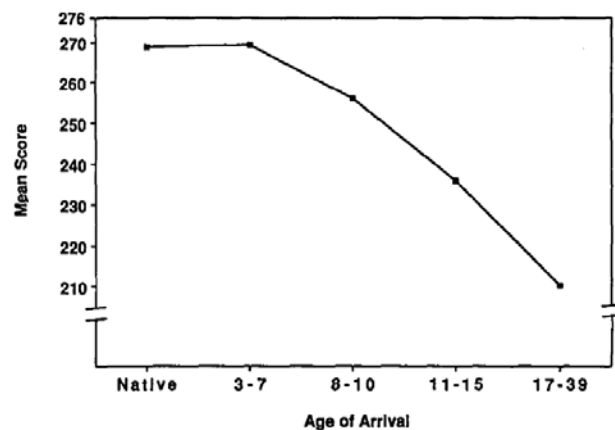
Johnson & Newport (1989): testing grammatical competency of Chinese & Korean natives living in the US

Heard recorded voices speaking sentences, and had to judge whether they were correct or not.

“The farmer bought two pig at the market.”

“Tom is reading book in bathtub.”

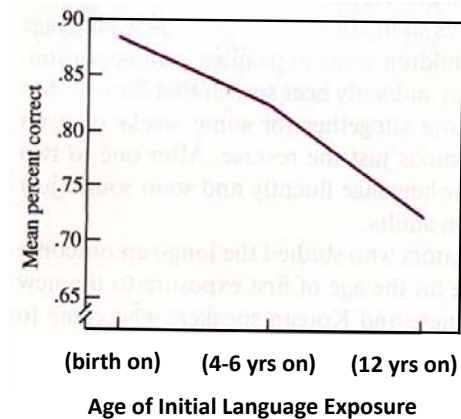
Second-language proficiency dependent on age of initial language exposure (even with same number of years of exposure total)



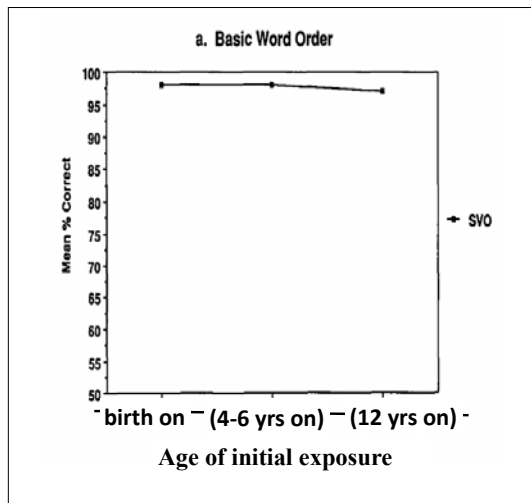
Second-language proficiency dependent on age of initial language exposure

Morphology:  
e.g. **verb agreement** in production

Tom **is**/\***are** reading book  
in bathtub



Second-language proficiency dependent on age of initial language exposure – but not all aspects are dependent



Basic word order: **SVO**

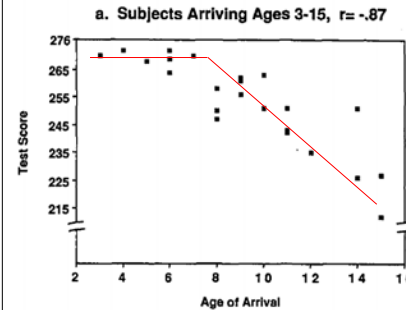
Subject Verb Object

Ex: "Penguins like fish."

As opposed to

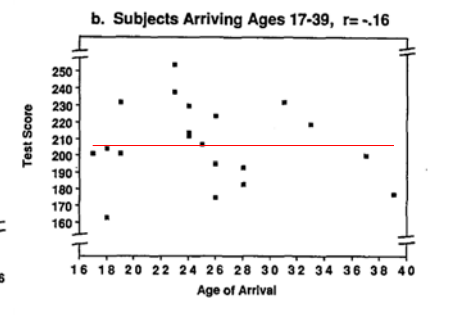
"Fish penguins like"  
(Object Subject Verb)

Before and after the critical/sensitive period (sometimes called "maturation")



During Maturation

Decline in ability with maturation.



After Maturation

No relationship between Age of Arrival and Test Score

## Some evidence for critical/sensitive period

Johnson & Newport (1989) also found that performance was not correlated with:

- Formal instruction in English
- Amount of initial exposure to English
- Reported motivation to learn English
- Self-consciousness in English
- Identification with American culture

## Some evidence for critical/sensitive period

Functional magnetic resonance imaging (fMRI) studies confirm **different neural processing for language** in individuals who learned before age 7 to 8 vs. individuals who learned after this age (Kim et al. 1997, Dehaene et al. 1997, Wartenburger et al. 2003, Saur et al. 2009)



## Some evidence for critical/sensitive period

Event-related potential (ERP) studies confirm differing **left-hemisphere specialization for language** in individuals who learned before age 4 vs. individuals who learned between 4 and 7 vs. individuals who learned after 7 (Weber-Fox & Neville 1996, 1999, Isel 2005)



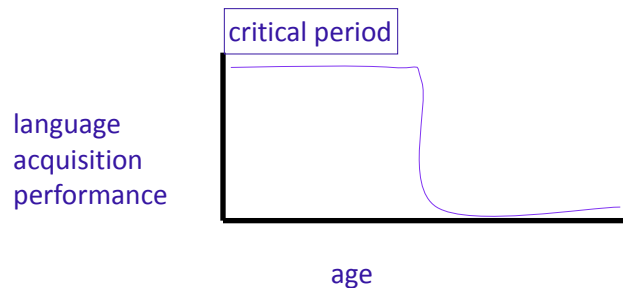
## Sum up: Critical/sensitive period

- Language learning is comparatively *effortless* before age 8 or so, extremely effortful after
- Applies to both first and second language learning
- Applies to spoken and signed languages
- Critical/sensitive periods similar to other biologically-programmed abilities in humans and other species

## Critical vs. sensitive, revisited

If there is truly a critical period of language acquisition, people learning language after this period should not succeed very well at all (they should be equally bad). In contrast, people within the critical period should do very well (they should be equally native-like).

Expectation: discontinuous function of performance



## Critical vs. sensitive, revisited

However, most of the evidence we've seen (including the one below) suggests that there is a **smoother drop-off**. (support for **sensitive period**)

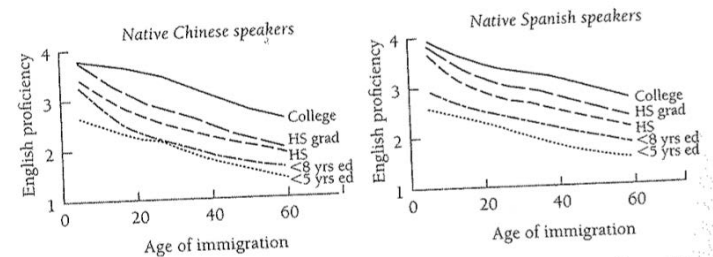


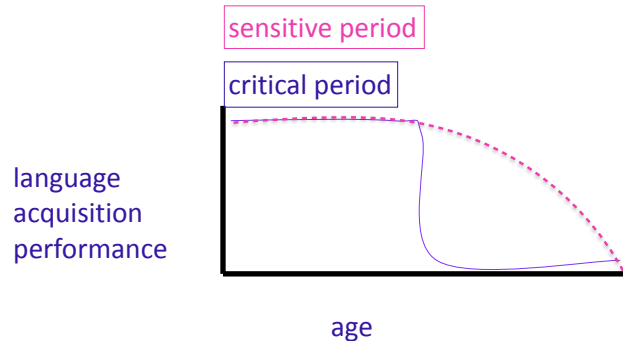
FIGURE 2.6 | THE RELATION BETWEEN AGE OF IMMIGRATION AND ENGLISH PROFICIENCY FOR NATIVE CHINESE AND SPANISH SPEAKERS WHO IMMIGRATED TO THE UNITED STATES

Hakuta, Bialystok, & Wiley 2003



## Critical vs. sensitive, revisited

Since we don't often see this sharp drop-off in performance, it's more likely there is a **sensitive period** for learning aspects of language, rather than a critical period.

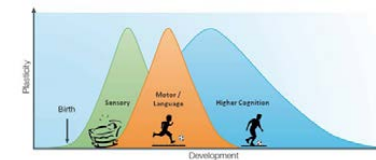


## Critical vs. sensitive, revisited

“...rather than postulating one critical period for language acquisition, a more plausible hypothesis is that grammatical development is characterized by several **sensitive phases**...a phase can be characterized by an optimal period for the acquisition of the phenomenon in question...characterized by a relatively **short onset**, followed by an extended **optimal period** and a **gradual offset**...”

– Meisel, 2013

Fig 1: Windows of plasticity in brain development



Adapted from Merrett, T. S. (2005). Critical period plasticity in local cortical circuits. *Nature Reviews Neuroscience*, 8(11), 977-986.

## So why are younger children better?

“Less is more” hypothesis: Newport 1991

Children can remember less than adults (and have other cognitive limitations, like less attention). **Perhaps language is actually easier to figure out if the input is limited to smaller chunks.** Adults remember more and can store longer chunks, which makes their analytical task harder.

Studies supporting the idea that a **limitation on the way children process input leads to better learning performance**: Phillips & Pearl 2012, Pearl, Goldwater, & Steyvers 2011, Pearl, Goldwater, & Steyvers 2010, Pearl 2009, Pearl & Lidz 2009, Pearl 2008, Pearl & Weinberg 2007, Dresher 1999, Lightfoot 1999, Lightfoot 1991

## So why are younger children better?

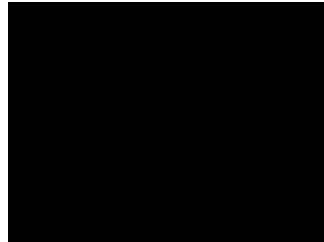
Some experimental support for the utility of “Less is more” when learning a foreign language as an adult: Chin & Kersten (2010)

Adults learning French over two one-hour sessions  
- full sentences vs. small phrases that incrementally increased length to full sentences (to simulate children’s steadily expanding processing abilities)

**Adults learning incrementally outperformed adults learning from full sentences on language proficiency tests of vocabulary and grammar.**



## Another African Grey Parrot: Einstein



[http://www.ted.com/speakers/einstein\\_the\\_parrot](http://www.ted.com/speakers/einstein_the_parrot)

Einstein, the African grey parrot, has a vocabulary of more than 200 words and sounds; she can perform nearly half on a cue from her trainer, Stephanie White. She can also impersonate a spaceship, a monkey and even a skunk.

Einstein in action: [http://www.ted.com/talks/einstein\\_the\\_parrot\\_talks\\_and\\_squawks](http://www.ted.com/talks/einstein_the_parrot_talks_and_squawks) [3:25-3:35]

## Parrot Points



The parrot language acquisition process seems to be very different from a human child's. The output of that process certainly seem to be — much more limited than a human's.

For example, the average adult human knows **tens of thousands of words**, not just a few hundred.

## Non-human primates



"He's pretty good at rote categorization and single-object relational tasks, but he's not so hot at differentiating between representational and associational signs, and he's very weak on syntax."

## Non-human primates



vicki



sarah & co.



washoe



washoe & louslis



Koko



nim chimpsky



lana & co.



kanzi & co.

## Teaching chimpanzees



Teaching chimpanzees to speak didn't work out very well

1930s: Gua, raised in a human home and treated like human infant along with the couple's son

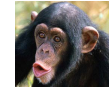
- motor skills surpassed child's, but never learned to speak (while the child did)

1940s and 50s: Viki, raised in a human home and actively taught to produce words

- by 6, Viki could say "mama", "papa", "cup", and "up"

**Problem:** Chimpanzees have a vocal tract that makes speech production essentially impossible.

## Teaching chimpanzees



Teaching chimps to sign using ASL

1960s: Washoe, lived in trailer in backyard, people always communicated via ASL, taught by molding hands into the appropriate signs

- June 1965: born
- 1-yr-old: Begins training
- 2-yrs-old: 13 signs
- 3-yrs-old: 34 signs
- 4-yrs-old: 85 signs
- 5-yrs-old: 132 signs
- 27-yrs-old: 240 signs



Findings (though controversial)

**New extensions**  
e.g., "dirty", "red"

**New word combination & syntax**  
e.g., "water bird", "baby in my drink."

Transmitted 50 signs to Loulis (adopted son).

## Teaching chimpanzees



Teaching chimps to sign using ASL

1979: Nim Chimpsky, raised in private home, taught signs by having hands molded into them

- learned 100 signs and produced some combinations

**But combinations produced are very different from those of a human child - very repetitive, no additional complexity:**

2-sign

"eat drink"

"tickle me"

3-sign

"eat me Nim"

"me Nim eat"

4-sign

"eat drink eat drink"

"play me Nim play"

## Teaching chimpanzees



Teaching chimps to sign using ASL

1979: Nim Chimpsky, raised in private home, taught signs by having hands molded into them

- learned 100 signs and produced some combinations

A quantitative analysis of combinatorial ability (called *productivity*) from Yang (2013) also demonstrates that Nim's productions are **not compatible with a combinatorial system**. Instead, they are much more likely to be imitations of whole chunks from the surrounding input. This is corroborated by reports of how Nim's sign combinations originated: All of them were imitations of his teachers - **no novel combinations, unlike human children**.

## Teaching chimpanzees

Teaching chimps to sign using ASL

Nim's longest utterance: "give orange me give eat orange me eat orange give me eat orange give me you"



## Teaching chimpanzees



Teaching chimps to sign using ASL

### No symbolic reference:

"For Nim, meaning seemed to have no role outside of the specific association between a form and its referent that had been explicitly taught to him....for Nim, signs did not refer; he did not have words - signs, or names - for things." - Laura Petitto, one of Nim's teachers, 1988

## Conversations with Koko



- *Moderator:* Koko are you going to have a baby in the future?
- *Koko:* Pink.
- *Dr. Patterson:* We've had earlier discussion about colors today.
- *Koko:* Listen! Koko loves eat.

....

- *Moderator:* What are the names of your kittens? (and dogs?)
- *Koko:* foot
- *Dr. Patterson:* Foot isn't the name of your kitty.
- *Moderator:* Koko, what's the name of your cat?
- *Koko:* no

....

- *Moderator:* Do you like to chat with other people?
- *Koko:* fine nipple
- *Dr. Patterson:* Nipple rhymes with people, she doesn't sign people per se, she was trying to do a "sounds like ..."

## Lana & friends

- The Lana Project (or LANguage Analog) established in 1971.
- Yerkish: Artificial language



## Teaching bonobos

[http://video.ted.com/talks/podcast/SusanSavageRumbaugh\\_2004.mp4](http://video.ted.com/talks/podcast/SusanSavageRumbaugh_2004.mp4)

Total length = 17:25, look at 2:32 - 7:32 especially



## Teaching bonobos

Bonobos (pygmy chimpanzees) vocalize in communication more frequently than common chimps do.



1981: adult bonobo Matata instructed with an artificial language and utterly failed

However, her **infant bonobo Kanzi** - who **wasn't explicitly instructed** in anything, but accompanied his mother when she was instructed - learned the artificial language and was also able to understand some spoken English (presumably because he was within the critical/sensitive period).

<http://www.youtube.com/watch?v=wRM7vTrIIs> (Lexigrams)

<http://www.youtube.com/watch?v=2Dhc2zePJFE> (Novel Sentences)

## Teaching bonobos

Did Kanzi have **reference**? Unclear.



“strawberry” = “I want to go to the place where strawberries are found”, “I want a strawberry to eat”, “There’s a picture of strawberries”, ...

Kanzi’s spoken English: comparable to a 2-year-old child’s performance (**but a 2-year-old’s syntactic knowledge is fairly limited**)

Also, Kanzi was 8 years old when he was tested, and was unlikely to improve his performance any further with age....unlike human children.

## A linguist’s concluding remarks



I do not believe that there has ever been an example anywhere of a nonhuman expressing an opinion, or asking a question. Not ever...It would be wonderful if animals could say things about the world, as opposed to just signaling a direct emotional state or need. But they just don’t.”

— Geoff Pullum

<http://www.smithsonianmagazine.com/issues/2006/november/speakingbonobo.php>

## So what's the problem?



Not a lack of intelligence - chimpanzees are highly intelligent.

One answer: language is an expression of a domain-specific mental faculty that humans have and other primates do not (nativist: generativist).

## A more detailed look at the nativist idea

Hauser, Chomsky, & Fitch 2002:

Faculty of Language – Broad (FLB): biological capacity for acquiring language that humans have and other animals don't. However, much of the biological capacity is assumed to derive from **shared origins with animal communication**.

Ex: Parts of the human conceptual system such as causal, spatial, and social reasoning are shared with other primates (Buttelman et al. 2007)

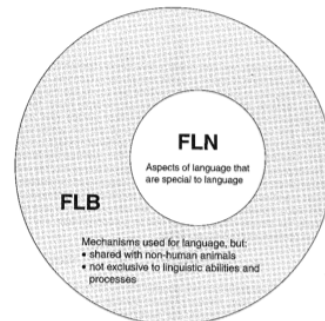
Difference between humans and animals is assumed to be more about **"quantity"** – humans have more power to drive these abilities than other animals, but the fundamental ability is basically the same.

## A more detailed look at the nativist idea

Hauser, Chomsky, & Fitch 2002:

Faculty of Language – Narrow (FLN): A subset of **Faculty of Language** abilities that only humans have. Biological underpinnings not shared with other animals. A difference of **"quality"** not just "quantity".

Pinker & Jackendoff (2005) suggest these might be in the FLN: properties of **speech perception**, **speech production**, **words** (as referential), **grammar**, **complex conceptual understanding that requires words** (ex: *week*, *10 feet from the blue wall*, *half past five next Tuesday*)



## Qualitative differences

Jane Goodall:

[http://www.ted.com/talks/jane\\_goodall\\_on\\_what\\_separates\\_us\\_from\\_the\\_apes](http://www.ted.com/talks/jane_goodall_on_what_separates_us_from_the_apes)



"The one thing we have, which makes us so different from chimpanzees and other living creatures is this sophisticated spoken language — a language with which we can tell children about things that aren't here. We can talk about the distant past, plan for the distant future, discuss ideas with each other, so that the ideas can grow from the accumulated wisdom of a group."

## Recap

There appears to be a period during which language is acquired most easily - whether this is a critical period or sensitive period may vary depending on what specific linguistic knowledge we look at.

The “less is more” hypothesis is one idea for why children’s minds might be more suited to language learning than adults’ minds.

When other animals try to learn human language, they are much slower and do not achieve a level of competency that a human child does.

This suggests that there is something special about human language. An idea about why is that there are aspects that are unique to human biology which make this possible.

## Questions?



You should be able to answer up through question 22 of the bio bases review sheet, and up through question 8 on HW1.