TOPIC # 11

UNDERSTANDING SYSTEMS & FEEDBACKS (cont.)

Class notes pp 57-61

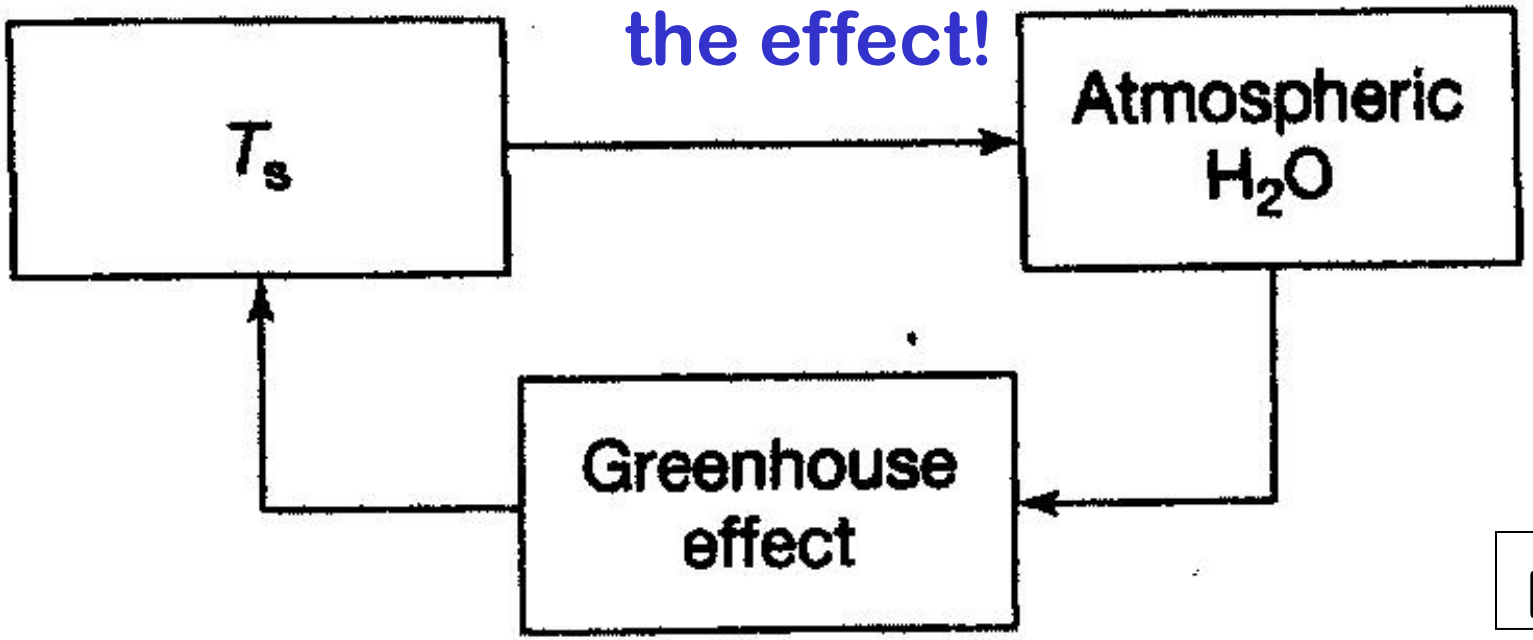
Review:

WATER VAPOR Feedback in the Earth-Atmosphere

What kind of FEEDBACK LOOP IS THIS?

Positive + OR Negative -

POSITIVE FEEDBACK LOOP that amplifies the effect!

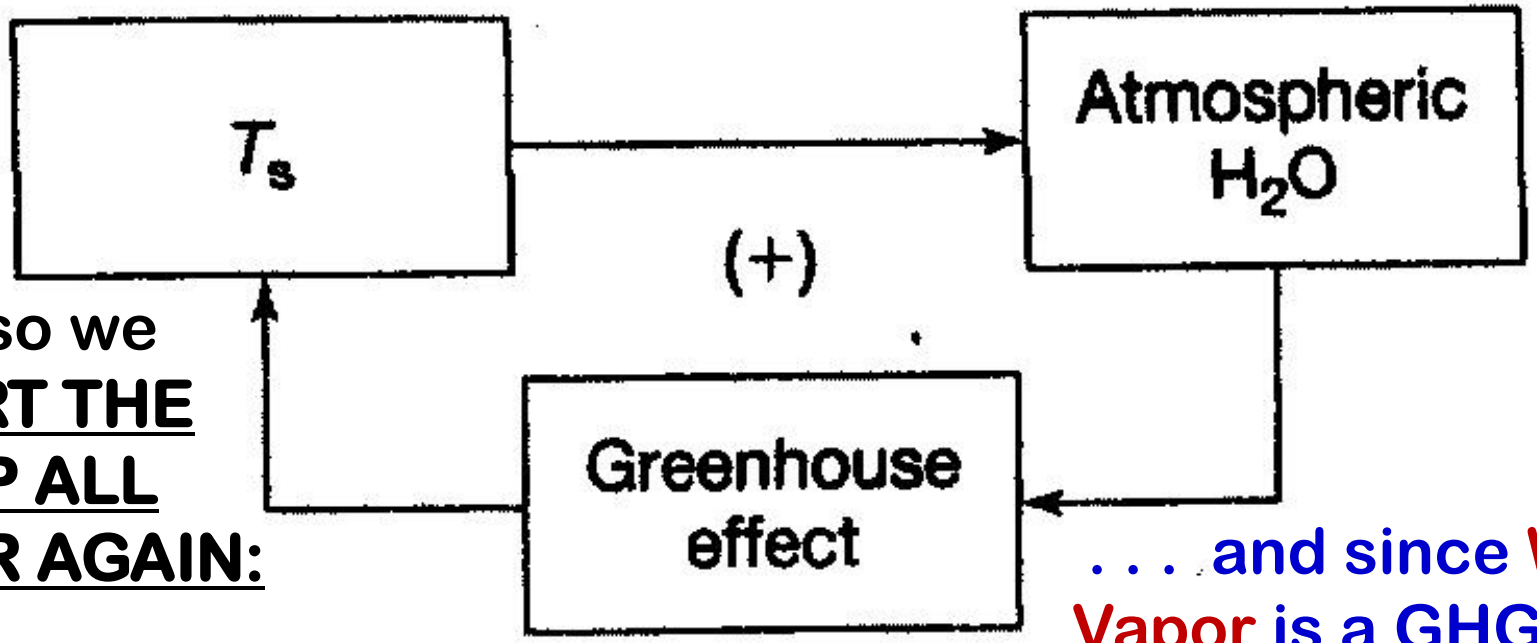


p 59

START HERE:

If the temperature of the Earth's surface (Ts) DECREASES ↓. . . .

. . . the colder temperatures will reduce evaporation, which will result in a DECREASE ↓ in the amount of Water Vapor in the atmosphere . . . . .



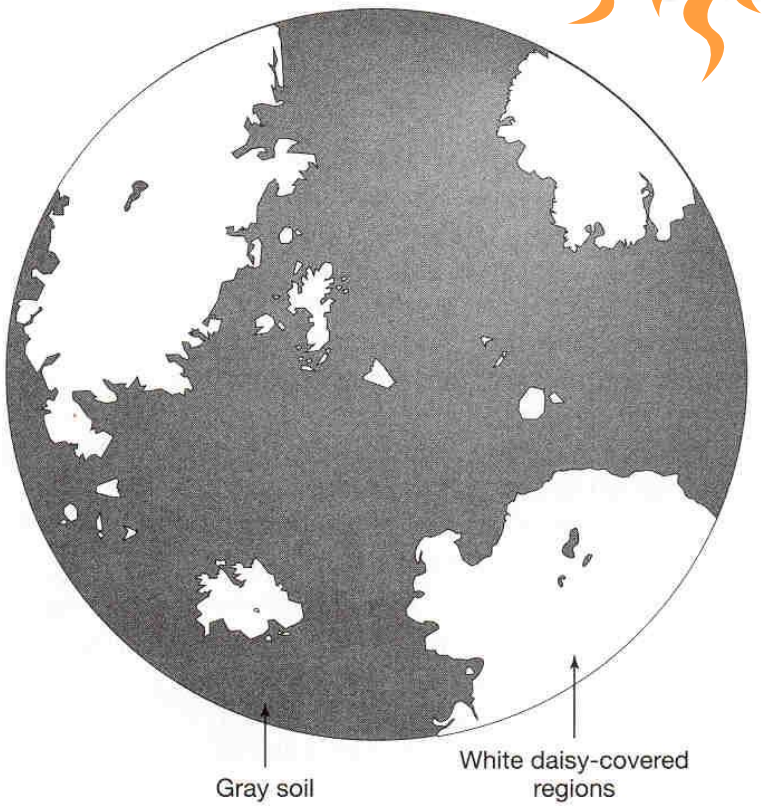
And so we **START THE LOOP ALL OVER AGAIN:**

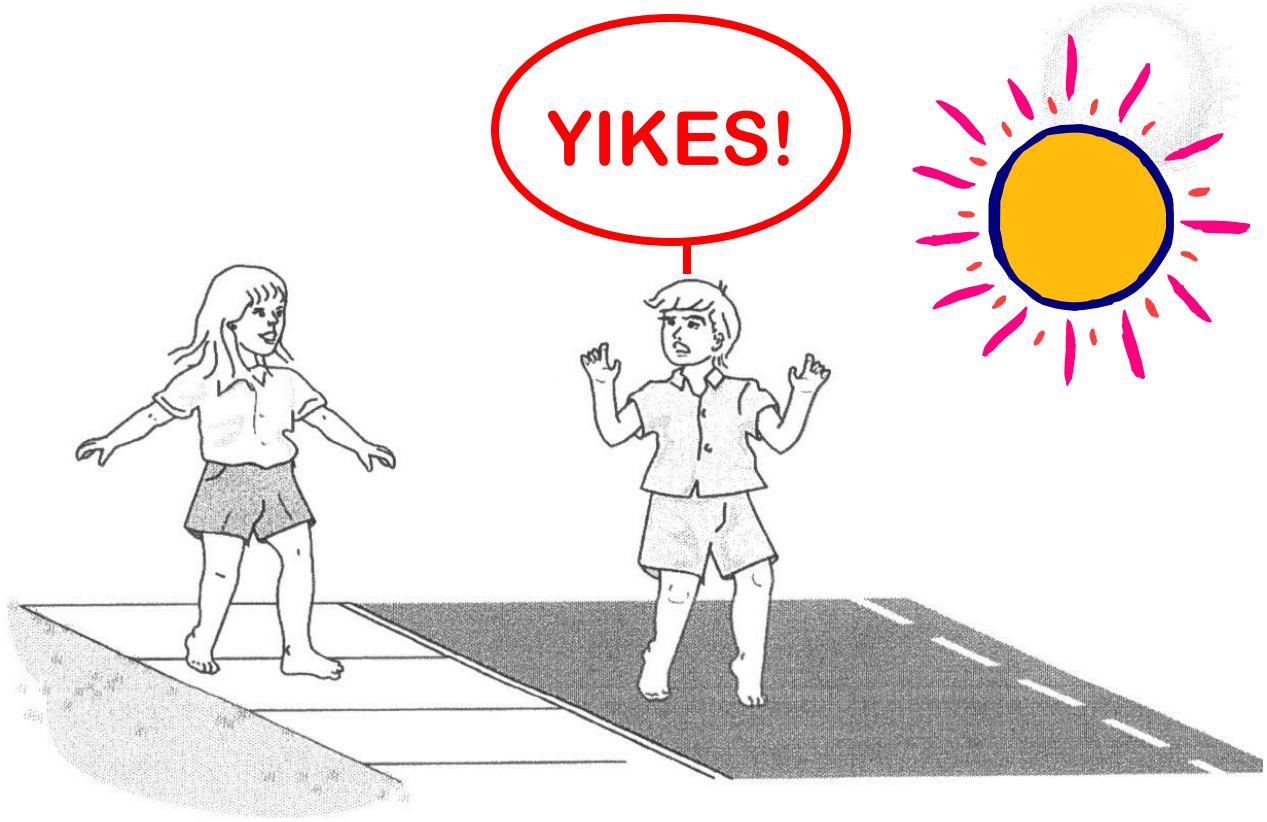
. . . and since Water Vapor is a GHG, the Greenhouse Effect will then DECREASE ↓ . . . .

. . . and with a weaker GHE, the temperature (Ts) will DECREASE further ↓

AMPLYFYING the initial perturbation!!

Ok, so what's this Daisyworld Climate System all about and why should I care??????





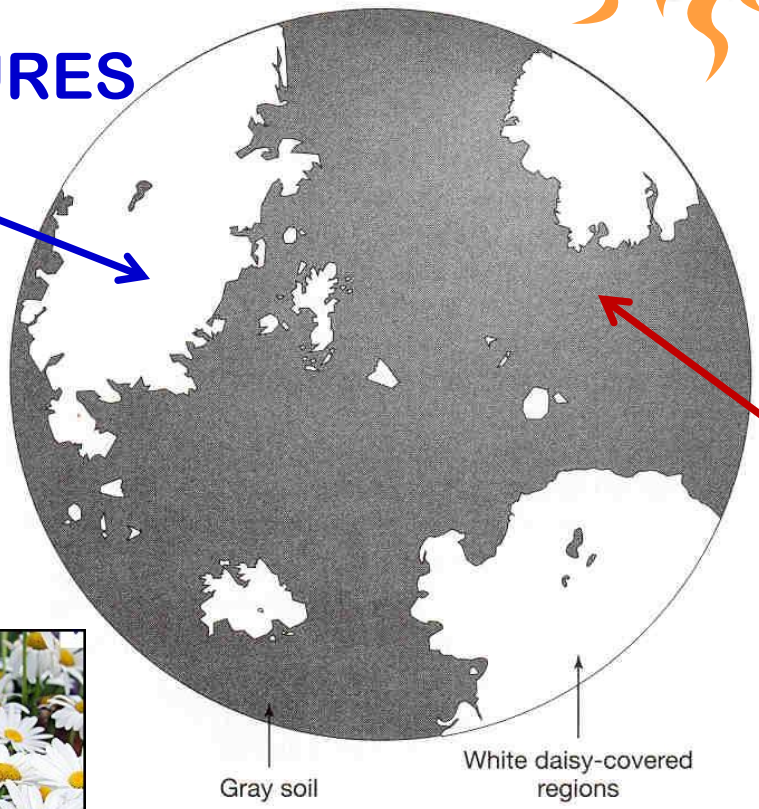
HIGH ALBEDO **LOW ALBEDO**

Review

HIGH albedo,
HIGH reflectivity,
& LOW absorption
➔ COOL TEMPERATURES

FEW or NO DAISIES

Lots of WHITE DAISIES

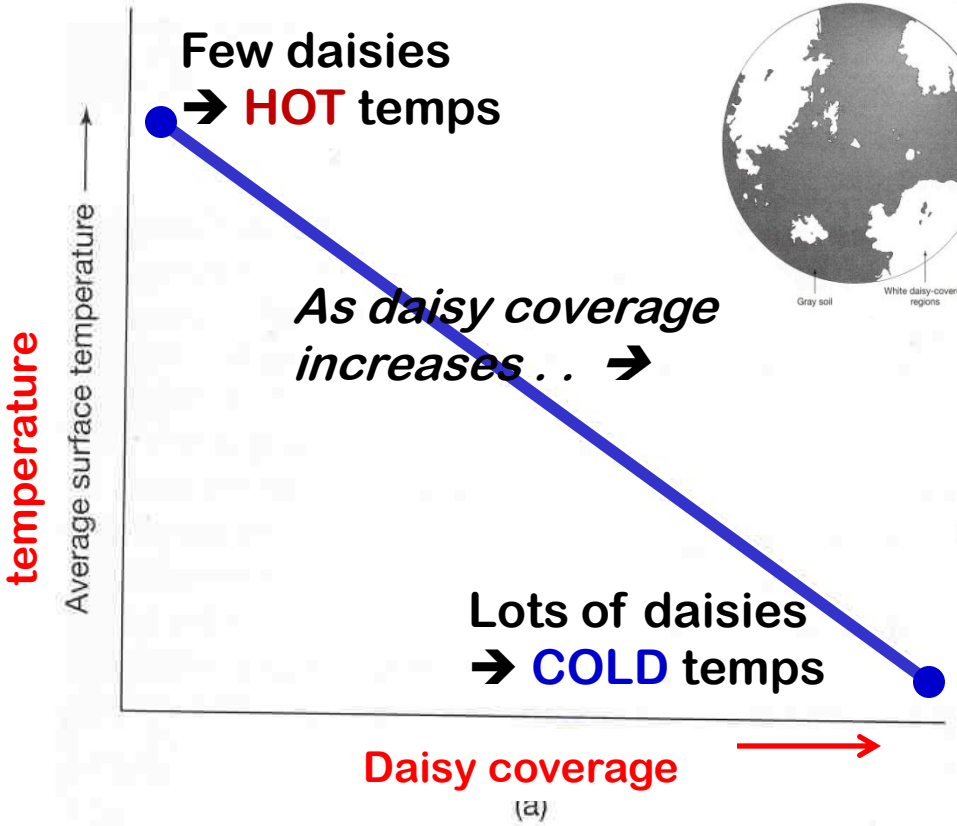


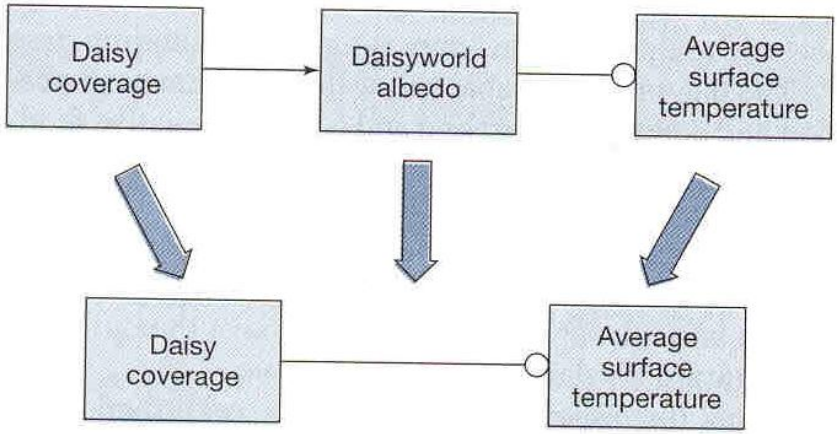
LOW albedo,
LOW reflectivity,
& HIGH absorption
➔ HOT TEMPERATURES

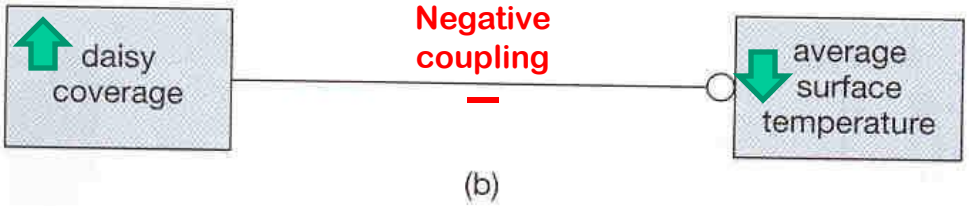
HOW DAISY COVERAGE AFFECTS TEMPERATURE:

An increase in daisy coverage ➔ a decrease in surface temperature

WHY? because more sunlight is reflected back (albedo increases) ➔ less sunlight is absorbed ➔ cooler temps







p 59

Now, let's think about the relationship between temperature & daisies in the OTHER direction!

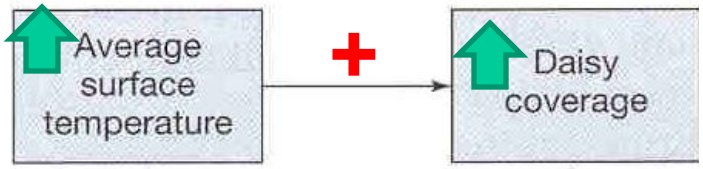
Instead of :

Daisy coverage ➔ Temperature

How does:

Temperature ➔ Daisy coverage

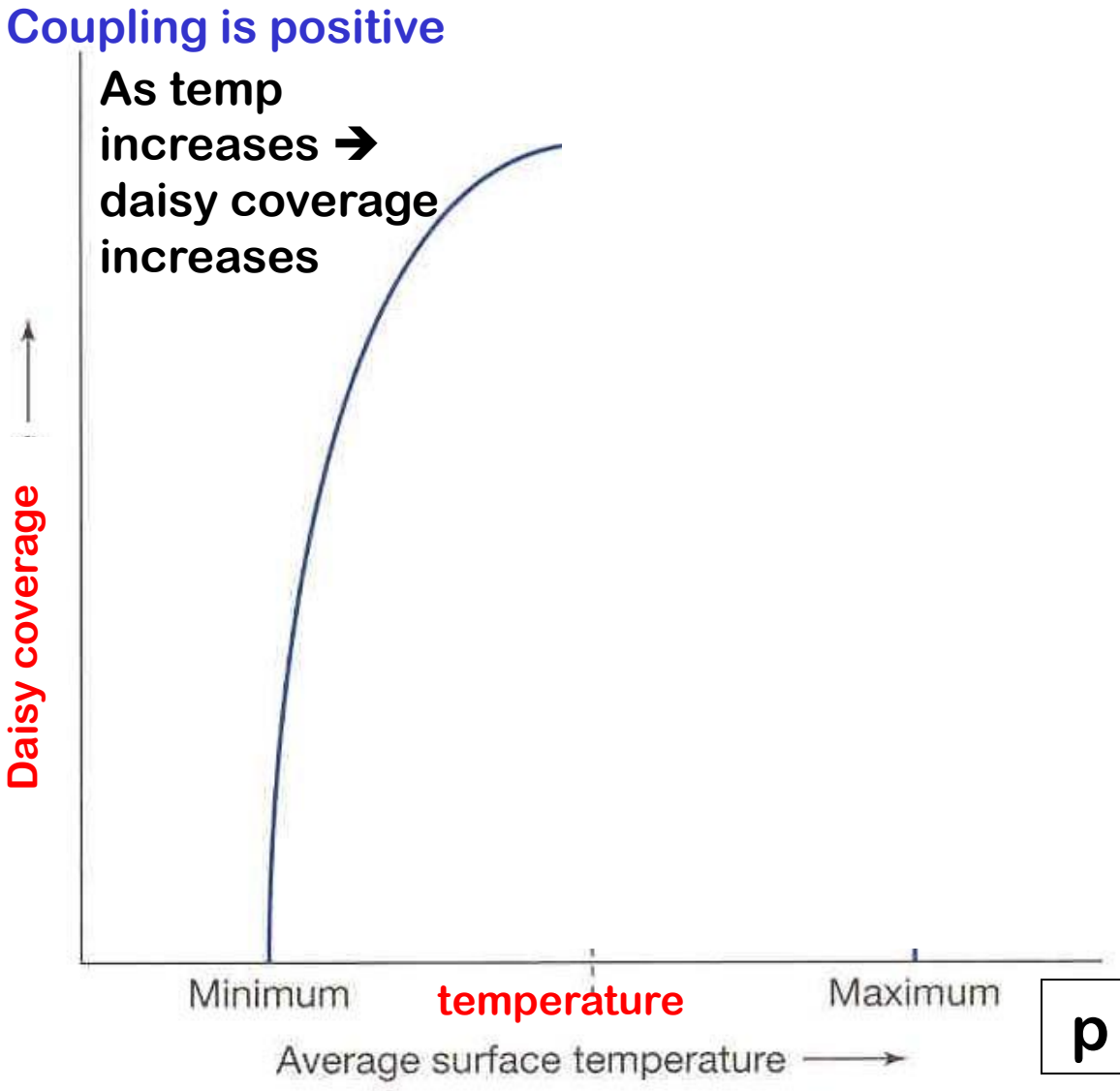
????



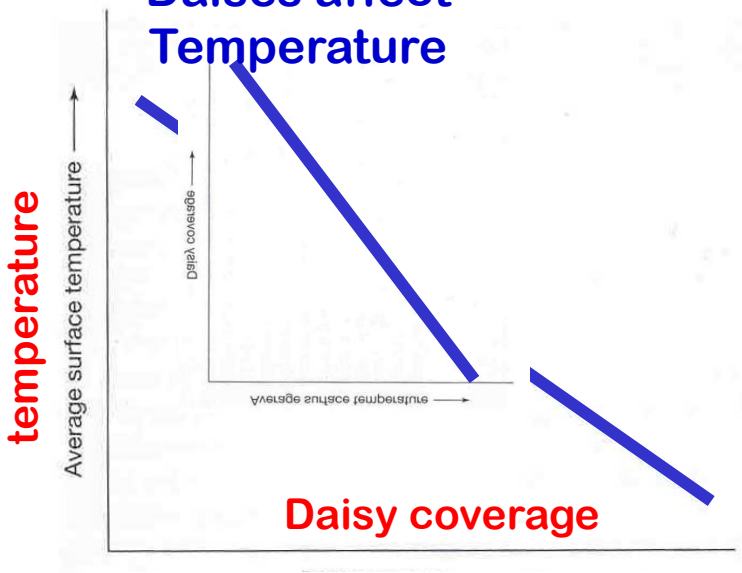
HOW DOES TEMPERATURE AFFECT DAISY COVERAGE?

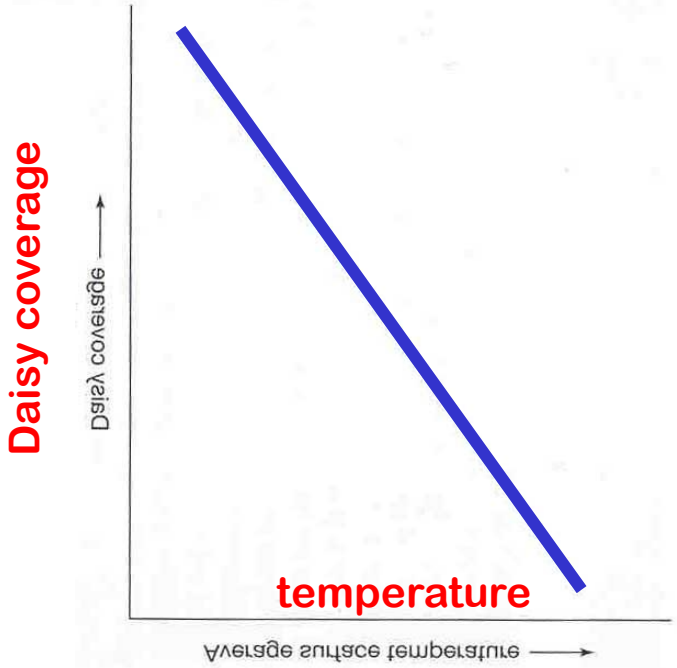
Daisies thrive in warm temperatures . . .

. . . until they reach some threshold temperature, then they start dying if it gets TOO HOT!



Daises affect Temperature

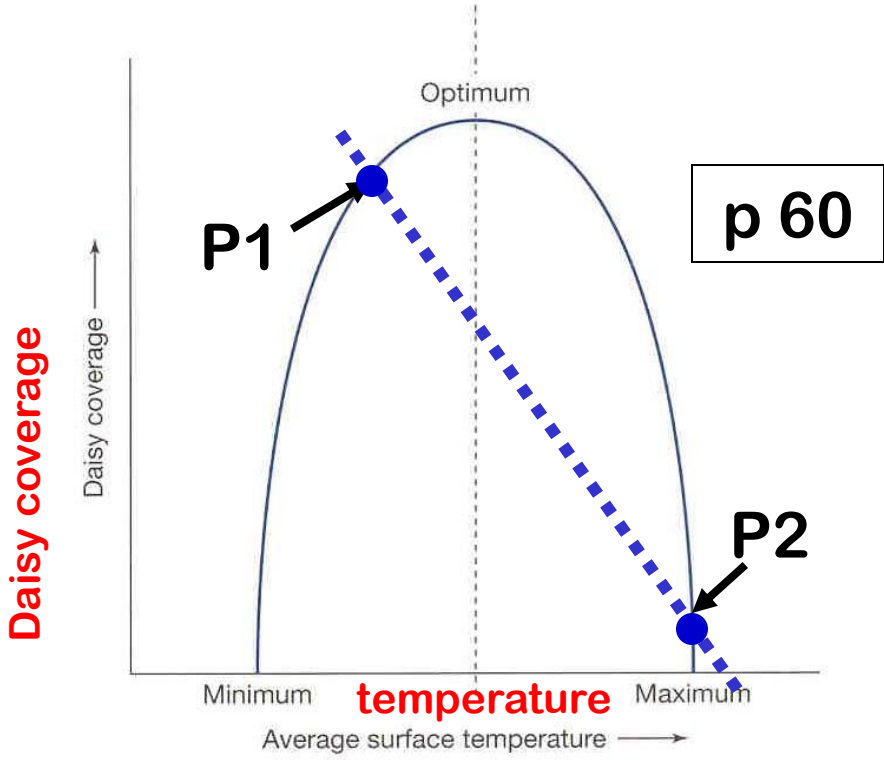




As daisy coverage goes up, temperature goes down

To put temperature and Daisy coverage effects <u>TOGETHER</u> on the same graph with the axes in the same place – a 'flip" is done

Temperature affects Daisies

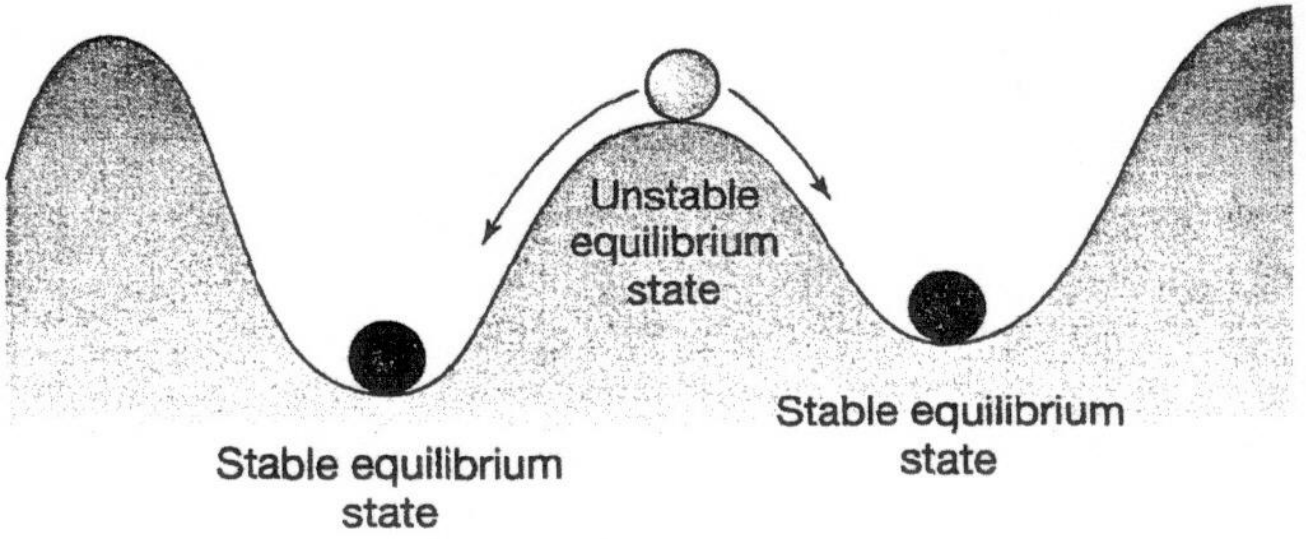


p 60

As temp goes up, daisies increase, but only to a point, then they begin decreasing

P1 and P2 are:

EQUILIBRIUM STATES



Defined:

EQUILIBRIUM STATE

= a state in which a system is in equilibrium

stated another way:

= the state in which the system will remain unless something disturbs it.)

An equilibrium state can be:

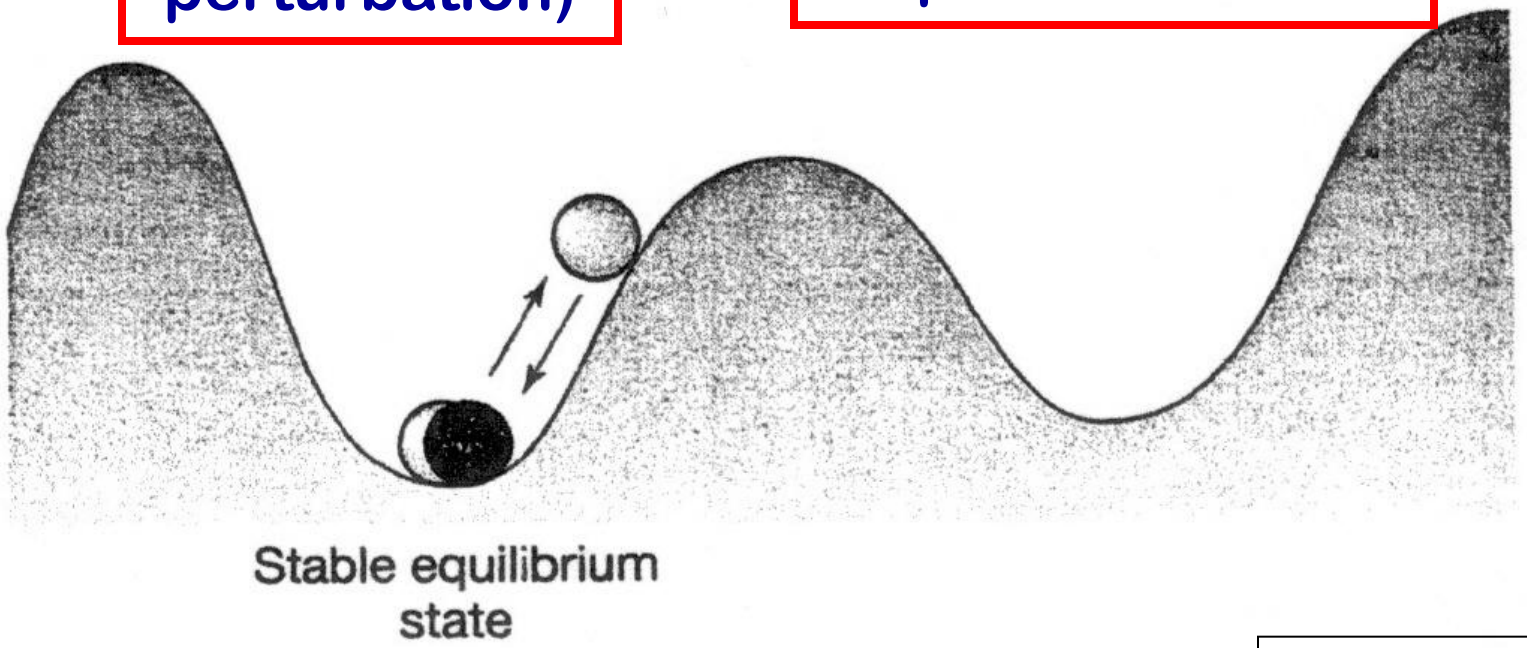
stable or unstable.

A negative feedback loop
(can also be described as)
a STABLE EQUILIBRIUM STATE :

A modest disturbance (short-term perturbation)

→

response that tends to return the system to its equilibrium state

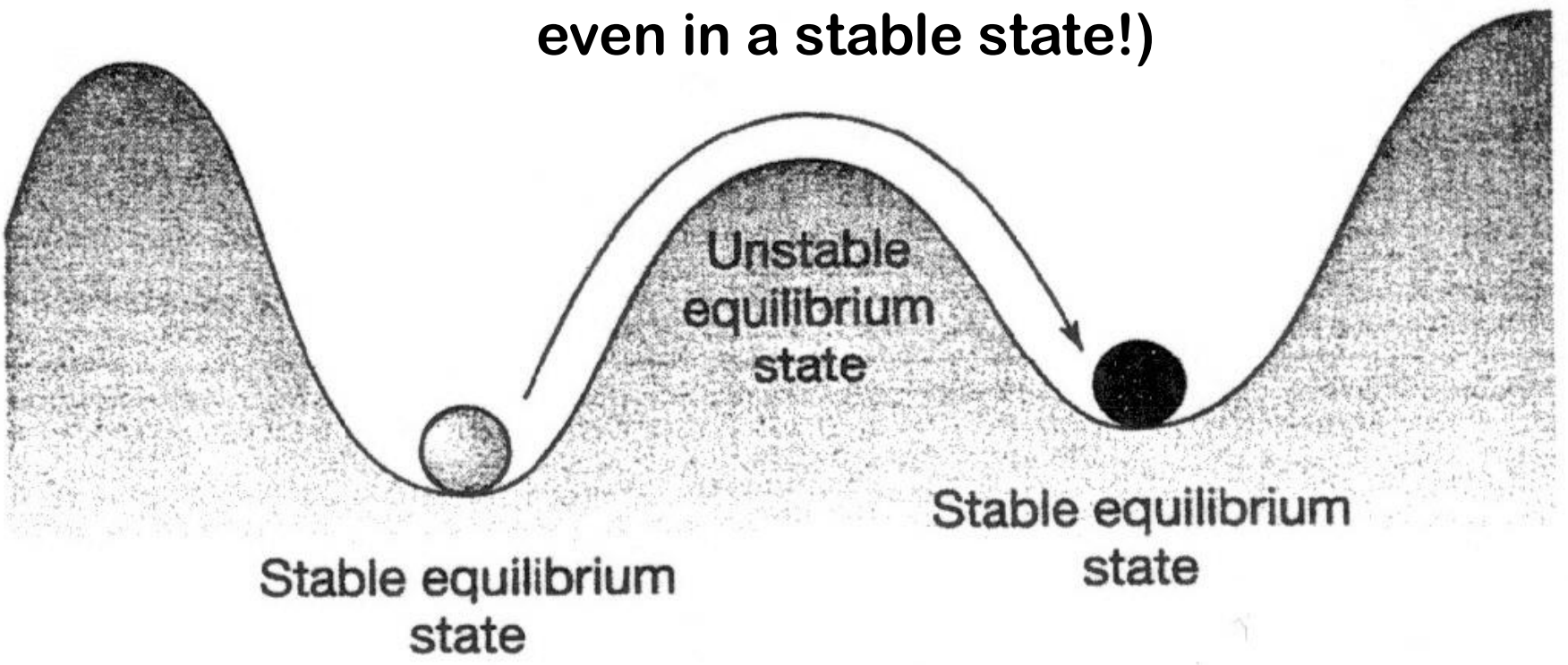


Stable equilibrium state

See this figure on p 60

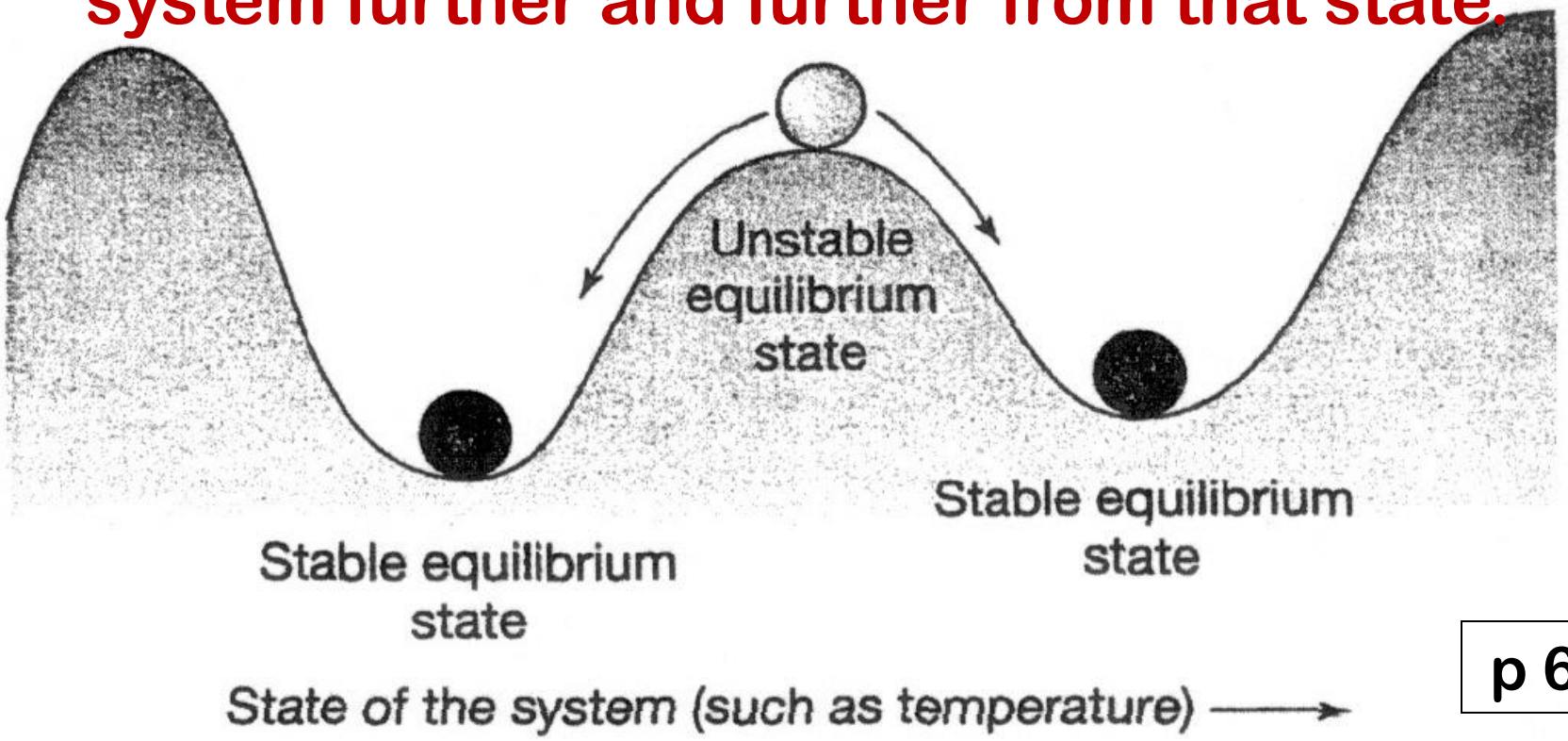
A **LARGE OR MORE PERSISTENT DISTURBANCE** (a forcing) can carry the system to a **different STABLE equilibrium state**

(so there area some limits to stability, even in a stable state!)

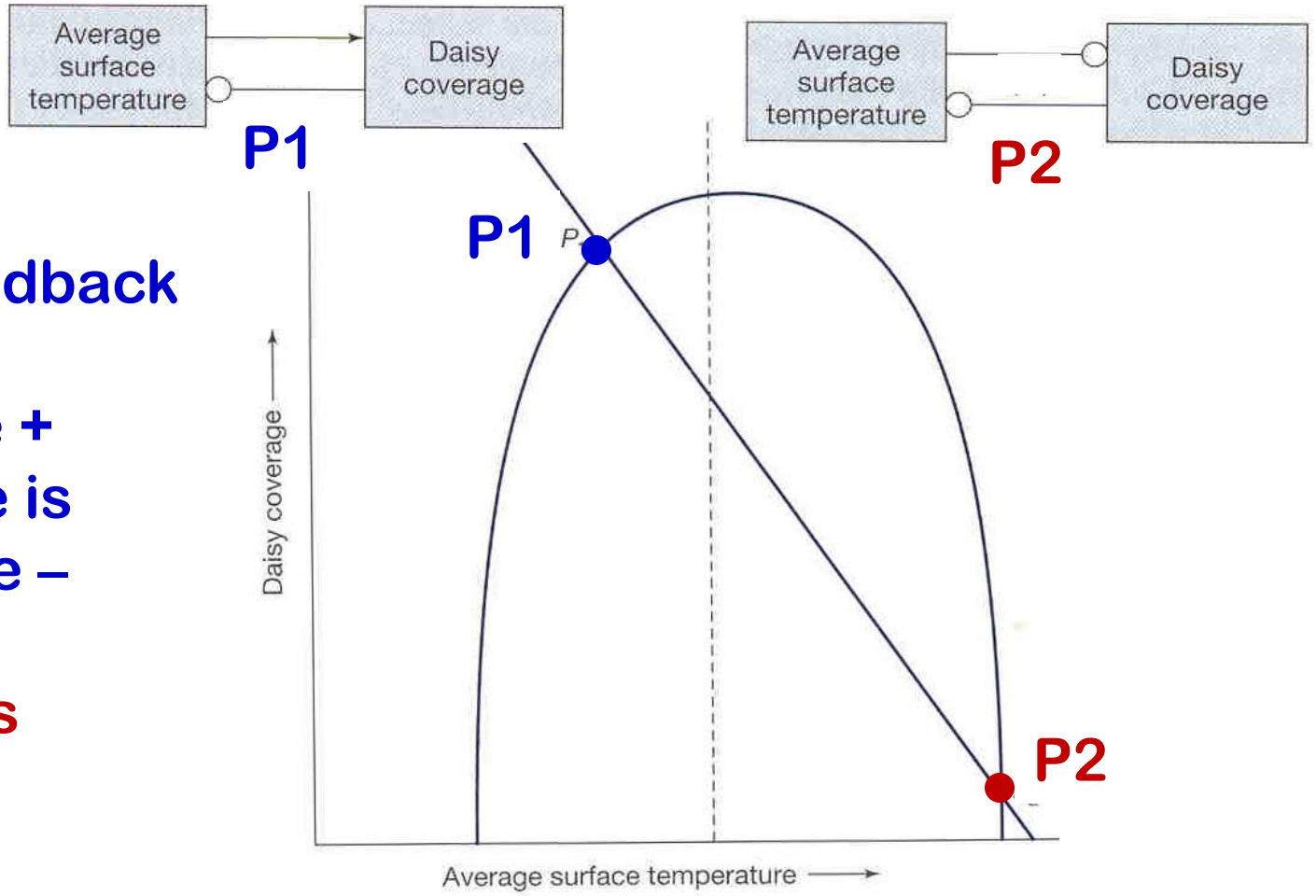


A positive feedback loop can also be described as an UNSTABLE EQUILIBRIUM STATE :

the slightest disturbance from a comfortable state may lead to system adjustments that carry the system further and further from that state.

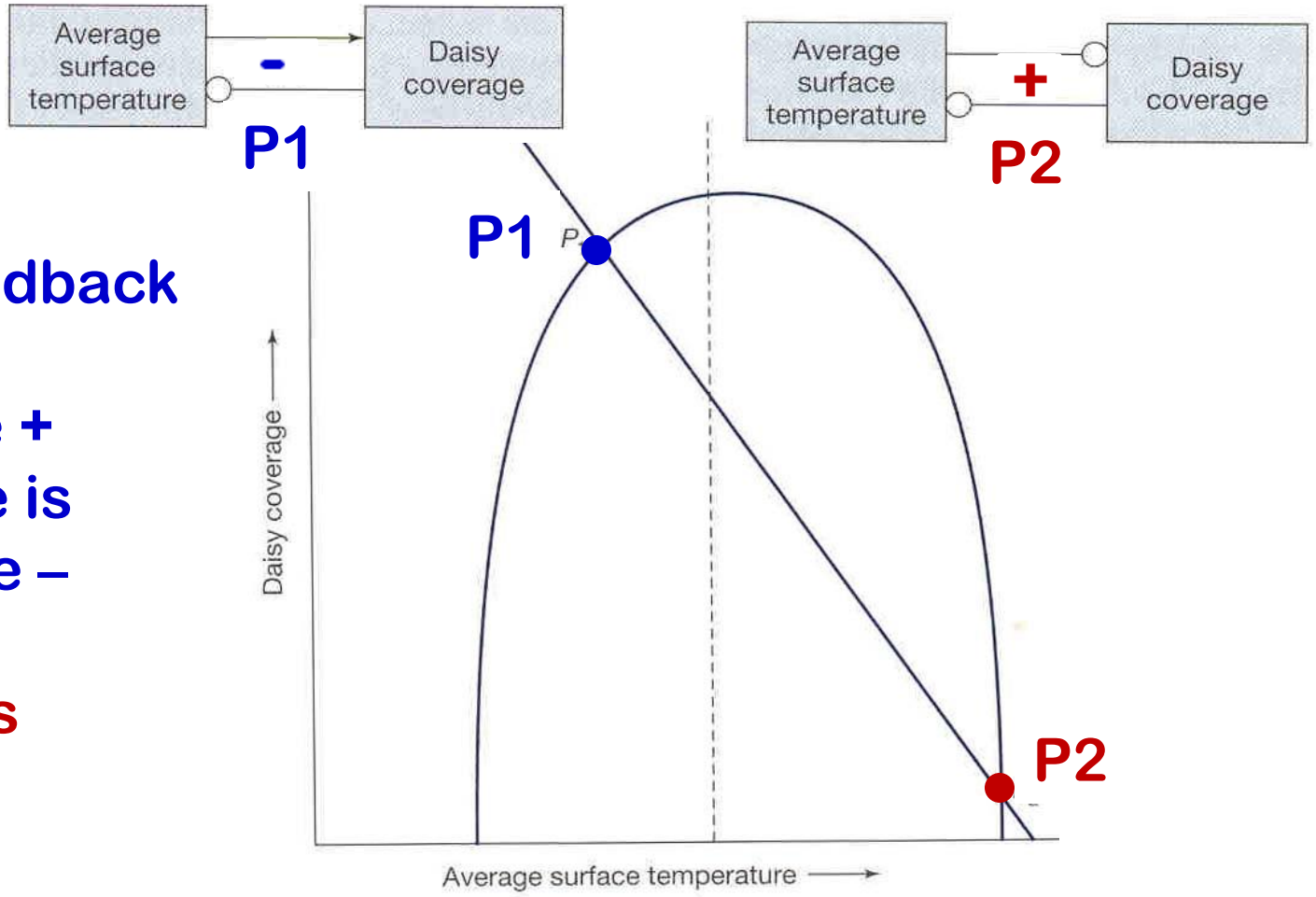


P1 and P2 each have their own FEEDBACK LOOP!



One feedback loop is positive + and one is negative –

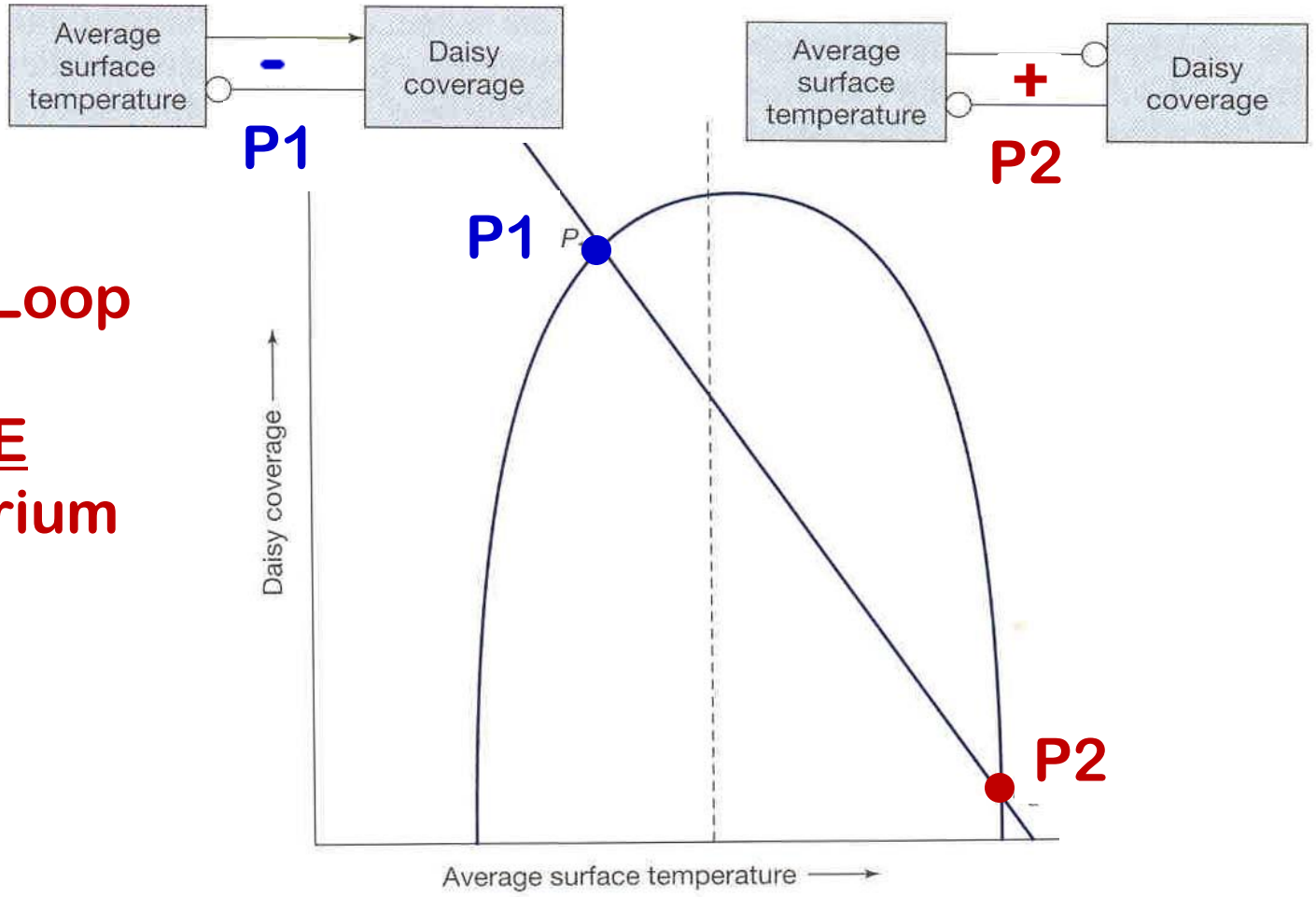
Which is which?



One feedback loop is positive + and one is negative –

Which is which?

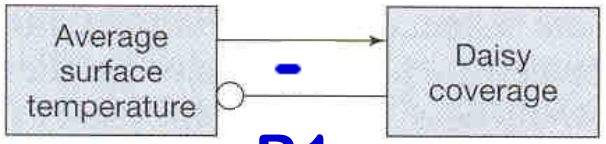
P1 is negative & P2 is positive



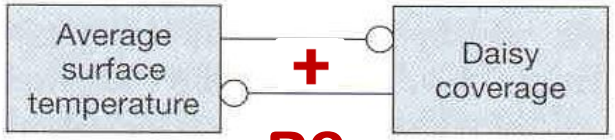
Which Loop is in a <u>STABLE</u> equilibrium state?

Is P1 STABLE
or
Is P2 STABLE??

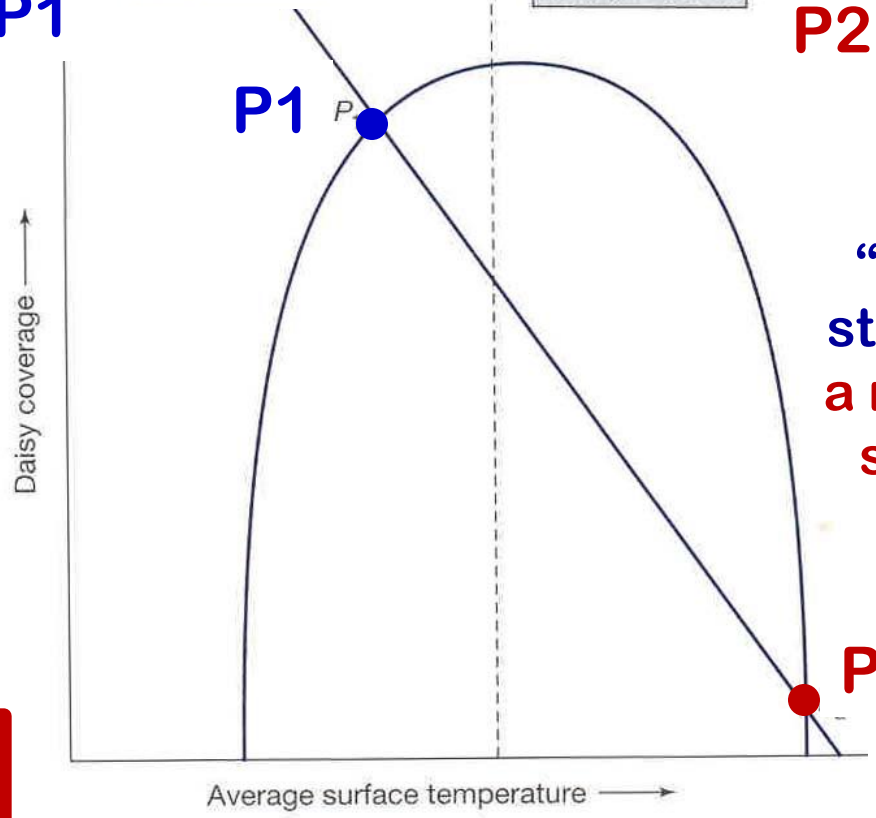
Self regulating feedback: STABLE **Amplifying feedback: UNSTABLE**



P1



P2

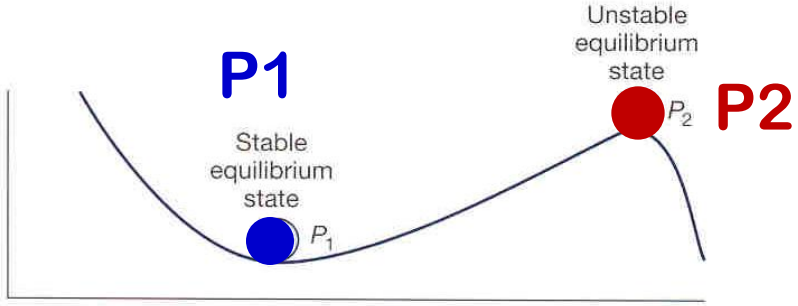


Which Loop is in a <u>STABLE</u> equilibrium state?

P1 & P2 are <u>each</u> "EQUILIBRIUM" states, but P2 is in a more <u>precarious</u> state (unstable) than the P1!!

P1 is STABLE

P2 is UNSTABLE



p 60

RECAP/ SUMMARY

The presence of FEEDBACK LOOPS leads to the establishment of EQUILIBRIUM STATES

- **Negative feedback loops** establish **STABLE** equilibrium states that are resistant to a range of perturbations; the system responds to modest perturbations by returning to the stable equilibrium state

- **Positive feedback loops** establish **UNSTABLE** equilibrium states. A system that is poised in such a state will remain there indefinitely. However, the slightest disturbance carries the system to a new state.

The last part of Chapter 2 illustrates that:

FEEDBACK FACTORS that are negative provide a "buffer" from FORCINGS – they allow the daisies to survive LONGER after a climate change (e.g., an increase in solar luminosity) than they could have survived if NO feedback processes were in operation.

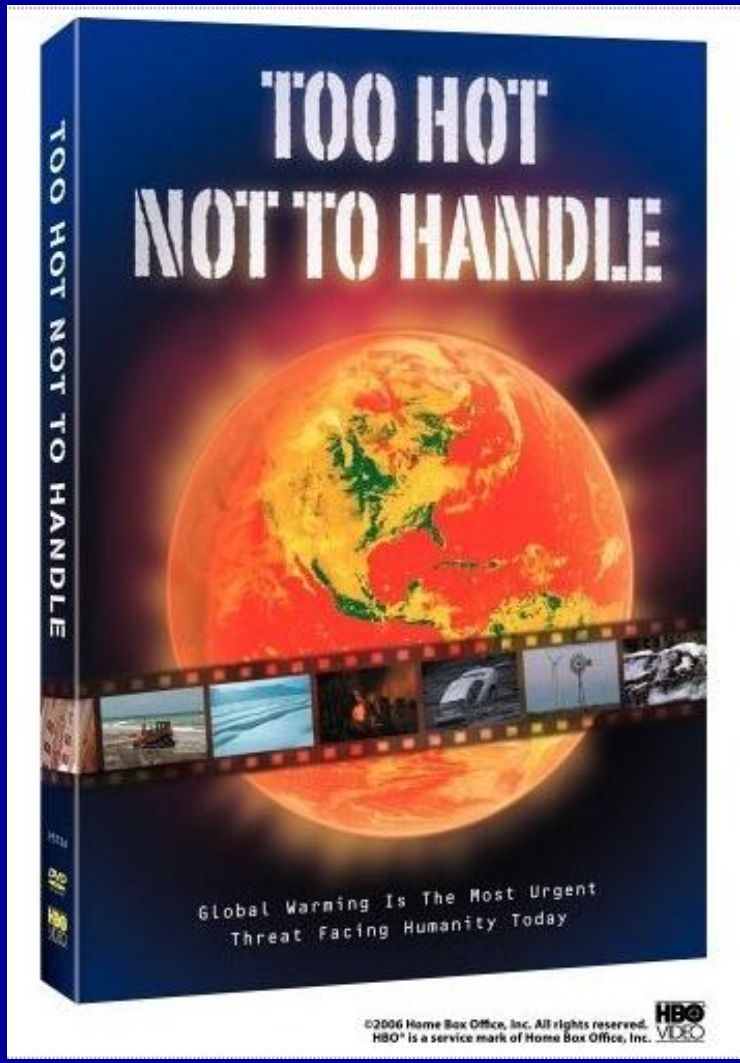
We will learn that this is EXACTLY what is happening on EARTH under many circumstances.

What we are worried about are the circumstances when feedback factors that are POSITIVE under a climatic FORCING.

Watch this short segment of the video carefully.

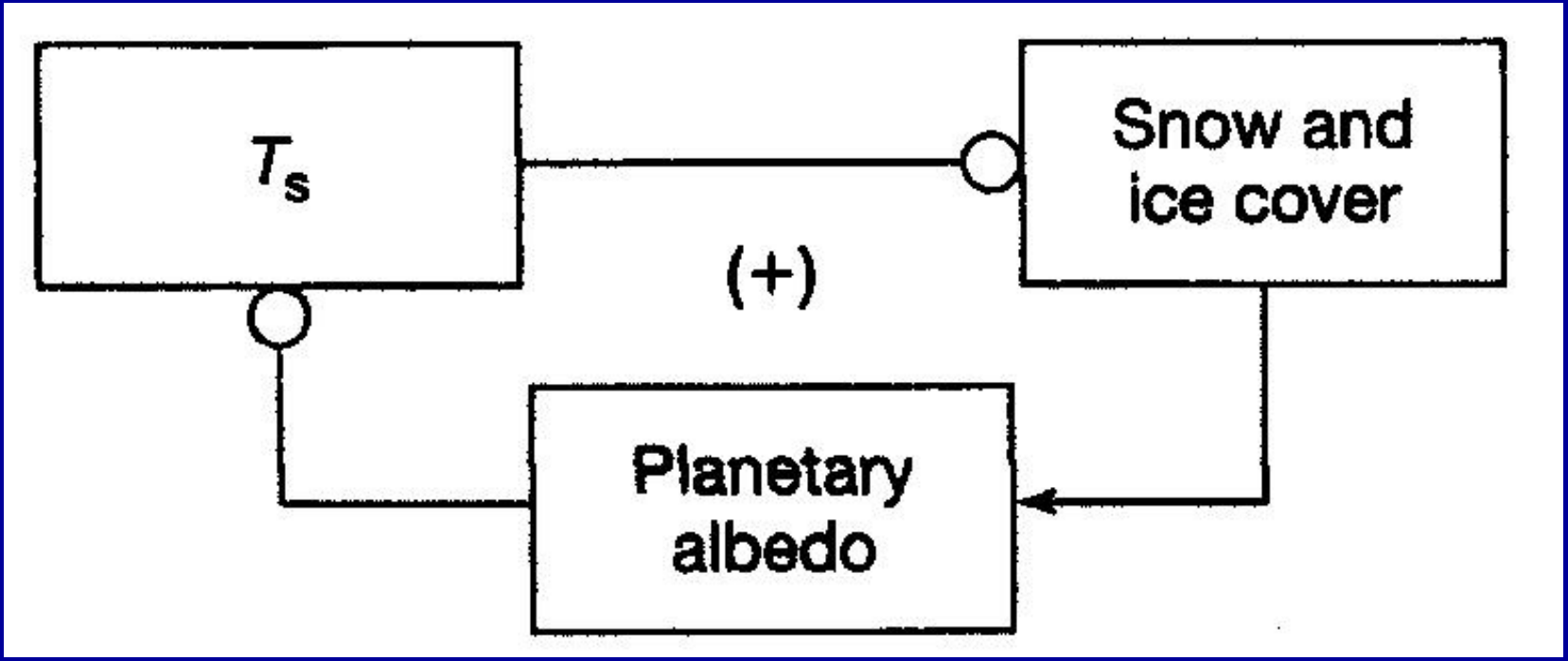
Can you recognize the FEEDBACK LOOP ???

(HINT: it is one of the loops shown on p 59 in Class Notes)



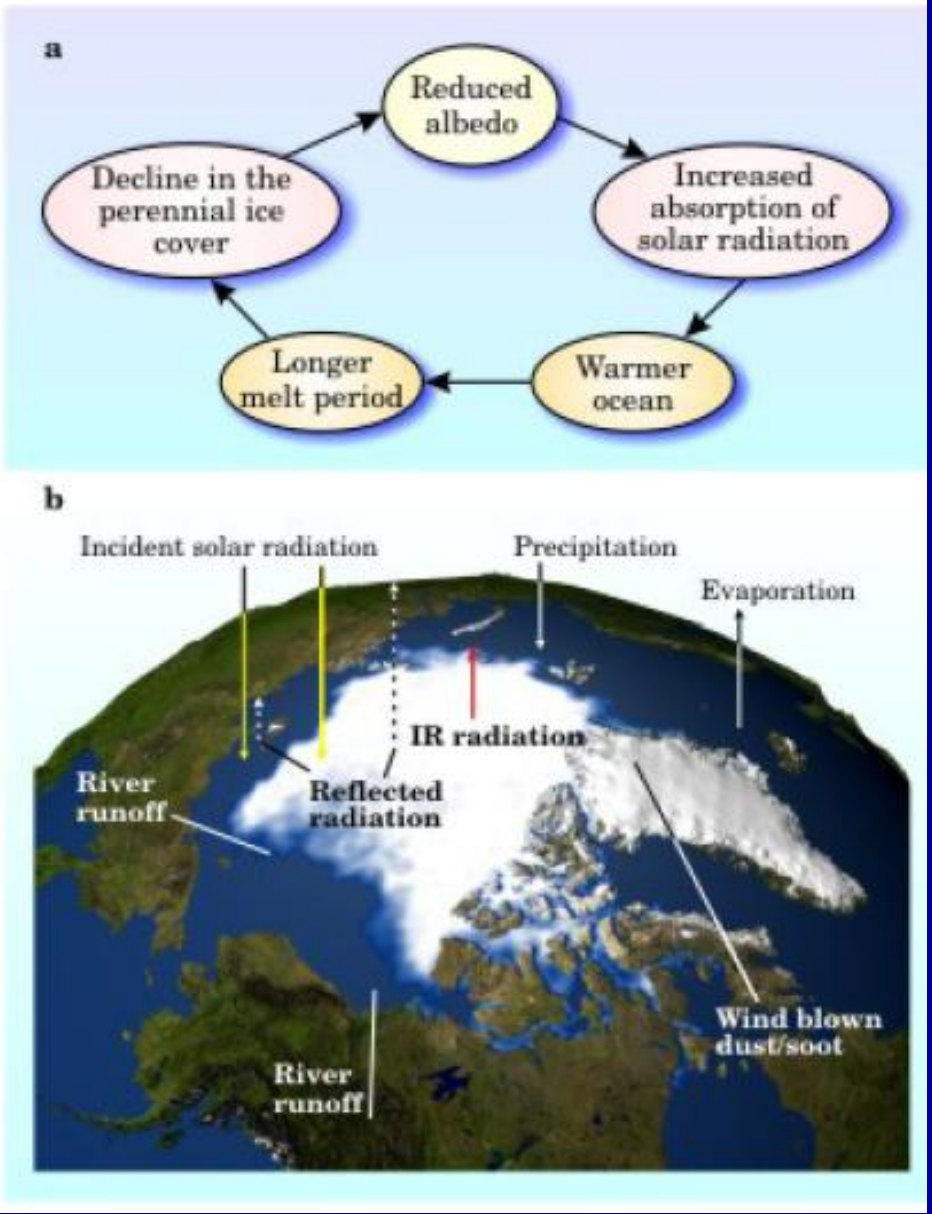
ANSWER!

SNOW AND ICE ALBEDO Feedback



GROUP BONUS POINT CHALLENGE

REMEMBER FEEDBACK LOOPS:
Is this one positive or negative?



GROUP BONUS POINT CHALLENGE !!

As a group, complete the feedback loop on the bottom of page 61 by linking the components with the proper coupling arrow symbols as used in the SGC text.

p 61

albedo

Extent of ice cover

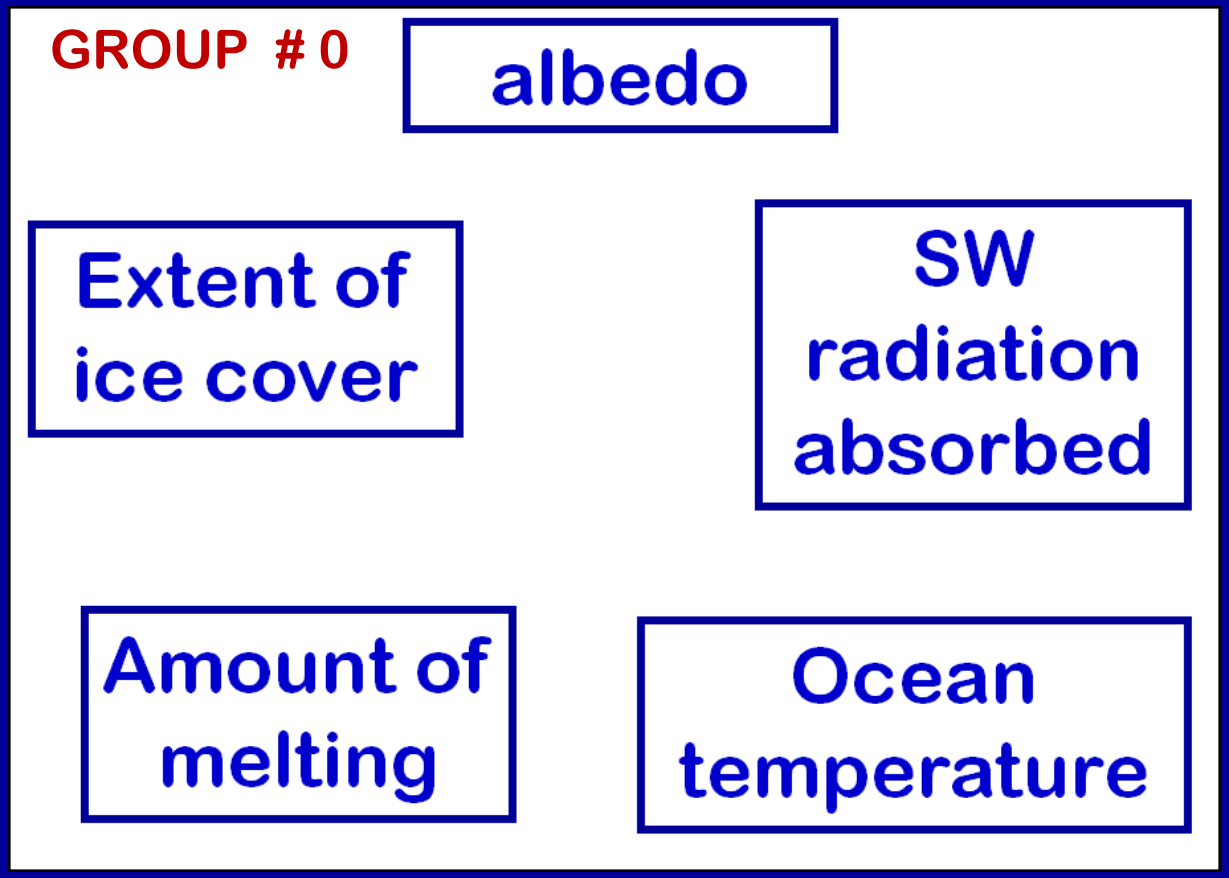
SW radiation absorbed

Amount of melting

Ocean temperature

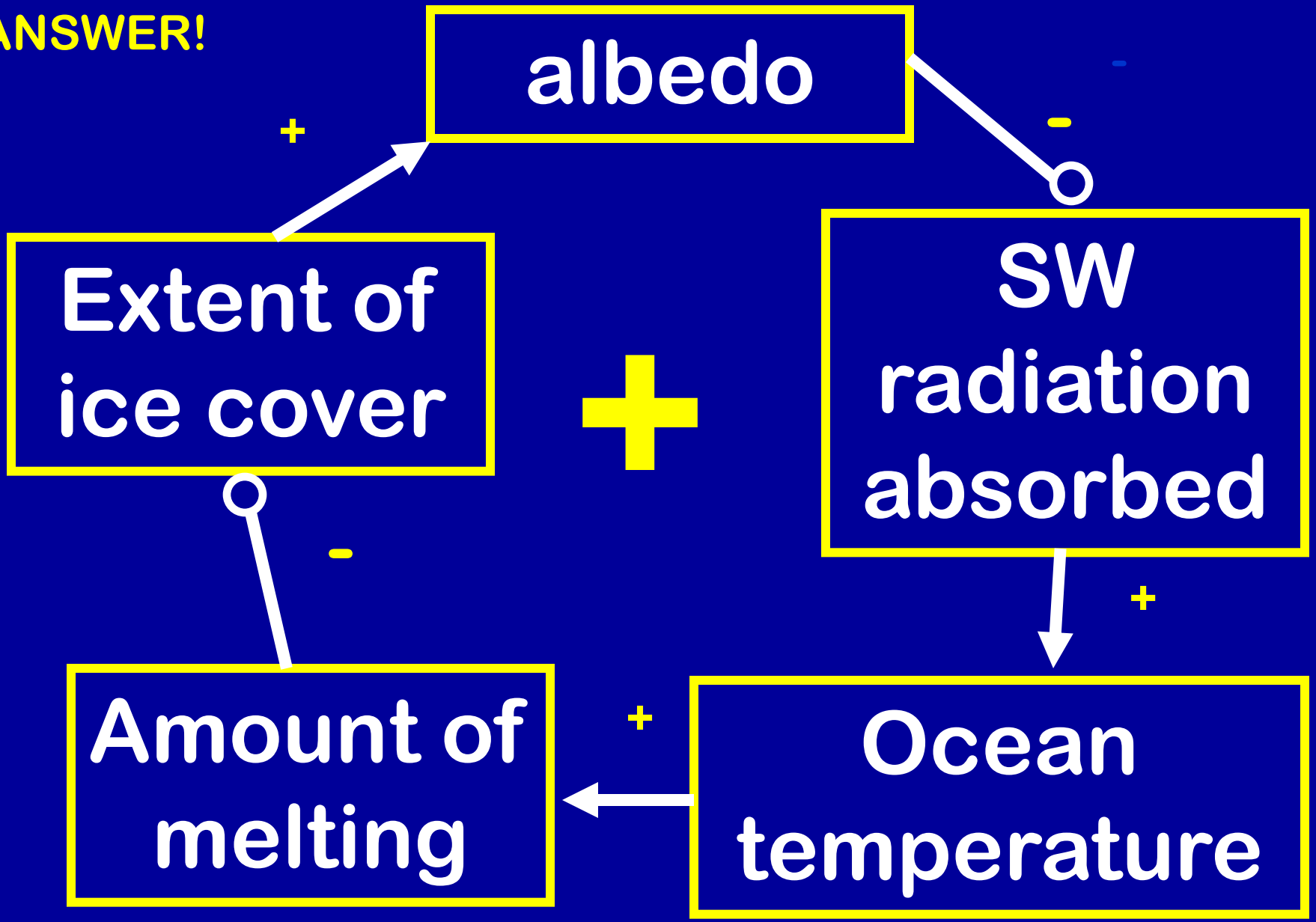
GROUP BONUS POINT DIRECTIONS

(1) WRITE YOUR GROUP # ON CARD
(2) Sketch in the component boxes
(3) Link them with proper + or – coupling symbols
(4) State if entire loop is + POSTIVE or – NEGATIVE
(5) Give Card to Dr H



THEN GO ON
TO COMPLETE G-4

BONUS POINT
ANSWER!



See you on MONDAY!

GO CATS!!